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NEW YORK, JANUARY, 1886.

WHO INVENTED THE QUADRUPLEX TELEGRAPH?

THE telegraphic competition which has been carried on with so much vigor and determination between the Western Union and the Baltimore and Ohio telegraph companies, seems likely to take a very unexpected turn, in consequence of a recent decision of the Commissioner of Patents to the effect that the first and original inventor of the quadruplex telegraph system, now in such extensive use by both these corporations, is not Thomas A. Edison, but one Dr. Henry C. Nicholson. The importance of this decision will be better understood when we say that the quadruplex system has become an absolute necessity in modern telegraphy. By its means one wire is practically made to do nearly as much work as four under the old system, and it needs but little calculation to discover that the annual saving in interest and repairs on the additional wires which would otherwise be required, would if capitalized amount to an almost fabulous sum, certainly not less than many millions of dollars. The absolute control of this invention by any one company would go a long way towards placing all successful commercial competition on the part of its rivals wholly out of the question except by the use of some essentially new method of accomplishing a similar result. This condition of affairs was clearly foreseen by the late president Orton of the Western Union company, and with characteristic sagacity he endeavored to secure for that corporation the monopoly of the quadruplex invention, while yet in its infancy. The story of his negotiations with Mr. Edison, of the peculiar financial operations of that erratic individual, comprising among other transactions, a sale of the invention twice over, once to president Orton and again to his rival Jay Gould, then president of the Atlantic and Pacific Telegraph Company, and the long, costly, and harassing litigation which followed, are no doubt fresh in the minds of our readers, and are at all events a matter of history. But these perplexing complications were the occasion of divers others, not quite so well known to the general public, and which are possibly yet destined to play an important part in the history of American telegraphy.

The sudden defection of Edison to the ranks of the enemy in February 1875, occasioned a feeling little short of consternation in the executive offices of the Western Union company. The quadruplex system was already in use on some of its most important lines, and the enormous prospective value of the invention was by no means unappreciated. In hurriedly casting about for means to protect the interest of his company, president Orton was informed of an invention by one Dr. Nicholson, hitherto principally known to fame as a medical practitioner in an obscure Kentucky village, which was claimed to be a practical quadruplex, and at once contracted with him to secure his rights, and the ownership of his patent, then pending in the Patent Office. Before the litigation in reference to the title of Edison's invention had terminated, so as to permit the patent to be issued, a second application for a patent was filed in behalf of Nicholson, which described and claimed a quadruplex apparatus not distinguishable either in principle or mode of operation from that of Edison. Interference proceedings were instituted by the Patent Office between the application of Edison and the two applications of Nicholson, in order to determine the question of priority of invention. In June 1878 the litigation in the state courts respecting Edison's invention was terminated by a decision of Judge Sanford confirming the title to the Western Union company, which thus became the owner of all the inventions involved in the interference.

In the meantime, another and equally inconvenient complication had arisen. It appears that Edison in the early part of 1875 on his own account, or more probably at the instigation of his new allies, had taken out a Canadian patent for a five years' term, a fact which at the time apparently escaped the knowledge of the Western Union people. This patent expired in April 1880, which circumstance, in accordance with a well-known provision of the patent law, rendered it forever impossible for a valid patent to be issued to Edison in the United States covering any of the essential features involved in his interference with Nicholson's application, thus practically, so far as his claim was concerned, throwing the invention open to the public.

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When the active managers of the Baltimore and Ohio company entered upon the present aggressive campaign against the Western Union, they were not slow to avail themselves of this state of affairs, which came about most opportunely for their purposes. A large proportion of their lines were at once equipped with quadruplex apparatus, and it is probably due to this fact alone that they have thus far been able apparently to more than hold their own in spite of the utmost efforts of their powerful rival.

We have already commented on the failure of the attempt of the Western Union company to enjoin the Baltimore and Ohio from using the Stearns condenser, one of the most essential appendages of the quadruplex, but it is now apparent that the Western Union has by no means played its last card. On December 15th three patents were issued to the Western Union company as assignees of Dr. Nicholson, broadly covering the apparatus known as the Edison quadruplex. The granting of these patents is of course *prima-facie* evidence that the interference proceedings have resulted in establishing Nicholson's priority of invention. This, however, is by no means the end of the matter. The patents have still to undergo the searching scrutiny of a court of equity, and we shall be very much surprised if Mr. Edison does not take a prominent position in the controversy. One thing is certain, if these patents are adjudged valid, the Western Union company has secured a monopoly, for seventeen years to come, of one of the most profitable inventions of the present day. In another column we have reprinted the specification and drawings of the most important of the three Nicholson patents, which we commend to the careful attention of all interested.

THE DYNAMO TESTS AT PHILADELPHIA.

We complete in our present issue the publication of the full report of the committee on the competitive tests of dynamo-electric machines which have been conducted under the auspices of the Franklin Institute. The character and ability of the gentlemen composing the committee are such, and the facilities at their command have been so unusual, that the results, as a whole, may be regarded as of greater practical value than any which have hitherto been rendered accessible to the public. It was hoped at the beginning that the comparison would include examples of all the leading dynamo-electric machines manufactured in the United States, but it ultimately narrowed down to a contest between the Edison machine entered by the Edison Electric Light Co., and the Weston machine entered by the United States Electric Light Co., four of the former machines and three of the latter having undergone a series of tests and measurements by the committee. Nevertheless, in view of the fact that of the whole number of dynamos now running in connection with incandescent lighting systems in the United States, by far the greater number are of one or the other of the two types tested, the value of the results is perhaps less seriously affected by this circumstance.

It may be remarked at the outset that the actual difference in the efficiency of the two rival machines as shown by the committee's figures is very small, and that both of them have given remarkably good results. No apparent change has been made in the design or construction of the Weston machine since the competitive test at the Cincinnati exposition two years ago. The Edison machine on the other hand has undergone material modification, both in its dimensions and in its proportions, the weight of the machine for a given output of electric current having been very greatly reduced, and the general design materially improved. It may be noted that in these changes it has approximated more and more closely to the proportions originally adopted in the Weston machine.

An inspection of the table of total and commercial efficiencies on page 17, shows that in both, the net efficiency becomes higher as the size and capacity of the machine is augmented. A comparison of the machines of each make most nearly corresponding in capacity shows a result somewhat, though not very largely, in favor of the Weston machine. The Philadelphia tests were in one respect a material improvement over any public measurements which have hitherto been made, in that an attempt was made to conduct them under conditions approximating as nearly as practicable those of ordinary use. This was effected by a prior agreement between the competitors that four separate tests should be made for the efficiency of each machine, one with a quarter load, one with a half load, one with a three-quarter load, and one with full load. These tests were made in each instance as soon as possible after the machine had reached its maximum of constant temperature under the given load, but it was provided that the full load test was to continue for at least five hours. This last stipulation proved to be rather severe on the Edison machines, the insulation of the armatures giving way in at least two instances. The percentages of efficiency under varying loads as given in the tables show a marked superiority of the Weston machine in this particular, which, as will be readily understood, is quite an important desideratum in actual service.

It has come to our knowledge that several experts of high standing have expressed distrust as to the absolute value of the dynamometer tests at Philadelphia as given in the tables, and the opinion appears to be quite prevalent that the measurements of the h. p. absorbed by friction of the armature in each of the machines tested are considerably too low. This is a matter which would seem to require further investigation and discussion, which it will no doubt receive in due time at the hands of the parties interested. On the whole therefore, it may be said that while the Franklin Institute tests are not absolutely conclusive as to the actual commercial efficiency of the several machines, they are at all events an extremely valuable contribution to the somewhat scanty stock of accessible information on the general subject, and when we consider the enormous difficulties in the way of carrying out and completing any absolutely satisfactory investigation of this kind, we cannot but congratulate the committee upon the measure of success in this direction which it has been able to attain.

GRAY, MEUCCI AND THE SPEAKING TELEPHONE.

Among the claims to the prior invention of the speaking telephone which have been brought into prominence in consequence of the proceedings before the secretary of

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the interior at Washington, for annulling the patents of Graham Bell, are those of Elisha Gray and Antonio Meucci. The history of Professor Gray's claim, although familiar to those who have heretofore kept themselves informed of the course of litigation under the telephone patents, appears to be very imperfectly known to the public at large, if we may judge from the general tenor of the articles which have appeared in the leading newspapers, and hence a brief statement of the facts in the case, as developed in the litigation referred to, may not be without interest. Prior to the year 1875 Professor Gray, whose abilities as a scientist and inventor were well-known in electrical circles, and Professor Bell, who had obtained equal eminence in another department of science as the originator and teacher of a system of vocal physiology, were independently at work experimenting upon the problem of transmitting intelligence by means of electrical vibrations. While pursuing this line of research, the attention of Bell became directed to the possibility of the telegraphic transmission of articulate speech, and on the 20th of January, 1876, he completed the preparation of an application for a patent, accompanied by a specification and drawings, describing among other matters an apparatus for the transmission of vocal sounds, identical with those in the patent afterwards issued, with the exception of an immaterial amendment, which, however, did not relate to the speaking telephone. On February 14, 1876, Bell's attorneys filed his application in the patent office. A few hours later on the same day, a caveat was filed by Professor Gray, also containing a description and drawings of a speaking telephone. The situation at that date was therefore briefly this: Bell had filed in the patent office a written description of a magneto-telephone, dating back at least to January 20th, 1876. Gray had filed a written description of a variable resistance battery telephone, dating back to February 10th. Neither of the inventors had reduced their form of the invention to practice. If the paper filed by Gray had been an application instead of a caveat, interference proceedings would necessarily have followed, and in such case, if each of the contestants had succeeded equally well in reducing his particular form of the invention to practice, it would have been inevitable, in view of the facts shown by the record, that the fundamental claim must have been awarded to Bell. An interference was in fact declared, but was almost immediately dissolved, and the Bell patent was issued on March 7th, 1876, without opposition.

The statement has lately been repeatedly made—and in fact forms the real basis of the proceedings at Washington —that Bell obtained improper knowledge of the contents of Gray's caveat, and therefore amended his own application so as to include Gray's invention. Not a particle of proof has been produced in support of the first part of this charge, but, on the contrary, any transaction of the kind is expressly denied by every person who could have been concerned in it, while the allegation that Bell's application was amended to include Gray's invention is absolutely false, as the records incontestably show. It should not be forgotten, that notwithstanding the issue of Bell's patent, it was still open to Gray to file an application and immediately institute interference proceedings. This, however, was not actually done until more than a year afterwards. Meantime Bell had constructed at least two telephones, the first shortly after the issue of his patent, which was an apparatus resembling Gray's, and embodying the same mode of operation, viz., by variable resistance, and the other a little later, consisting of a magneto-transmitter similar to the one described in his patent. In the case of the American Bell Telephone Company *v.* Dowd, in 1879, the defendant relied mainly on the Gray invention, the theory of the defense being that the apparatus described in the Bell patent was inoperative, while that devised by Gray was operative. If this point could have been successfully established, Bell's patent would have fallen to the ground, leaving Gray to pass into history as the inventor of the first successful speaking telephone. But the complainant produced in rebuttal a number of instruments in which the drawings of the Bell patent were followed with Chinese fidelity, and which transmitted speech with entire success. The counsel for the defense, in view of this indisputable fact, realized that the patentee must necessarily prevail, and accordingly advised their client (who was in fact none other than the Western Union Telegraph Company), to settle the case on the best terms it could. It is clear, therefore, that Gray's case turns wholly upon the question whether the description in the Bell patent is sufficient to enable an operative telephone to be constructed in the then existing state of the art. This issue was afterward raised in the Spencer case, and the court, deciding the case in favor of the patent, said, "The instruments will talk, and in the mode pointed out in the specification." Until this judgment is reversed by a competent tribunal it is difficult to see how the claim of Professor Gray can be established.

But little need be said of the claim of Antonio Meucci. The strongest evidence in his behalf is that afforded by his caveat of December 28th, 1871, which we reprint in another column. It is impossible to believe that any person who had ever had in his possession, or had worked upon or experimented with an apparatus capable of transmitting speech by electricity, could possibly have written such a document as a description of it. The express language of the writer excludes the idea of an electric telephone. It does indeed indicate that he entertained a vague notion that by electrifying the apparatus of a common string telephone, as well as the operators, the results would somehow be improved; but its phraseology leads one to believe that he had not even entered the region of experiment, much less that he had, as alleged, constructed, completed and operated a magneto-telephone, which he afterward, by reason of poverty, permitted to become abandoned and lost to the world. The Meucci story is simply a new version of the Drawbaugh claim, and one which cannot fairly be said to be in any respect more credible than that.

THE NATIONAL ELECTRIC LIGHT ASSOCIATION.

THE annual meeting of this association will be held at the Carrollton hotel, Baltimore, February 10, 1886. It promises to be the most interesting electrical gathering of the year. Full particulars as to transportation, accommodation and membership will be found on page xii of our advertisements.

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ARTICLES.

SUBTERRANEAN WIRES IN ENGLAND.

BY DAVID E. LAIN.

To an American, used to seeing the maze of electrical conductors of various kinds that are invariably strung overhead in his native cities, the smallness of the number of such aerial wires that he finds in London and other important cities of the British realm, must call forth the remark that the English people are either far behind their American cousins in the use of the more important electrical inventions or, that most of the electrical conductors rendered necessary by such conveniences, are hidden from view.

If he were to inquire into the matter a little more fully, he would find that both assumptions were in part correct, for, while it is true that all of the telegraph wires of this and many other cities of the British isles are placed underground, it is also true that in the use of the electric light and the telephone the citizens of London, at least, have made scarcely more than a beginning, some of the reasons for which will be shown to explain in a subsequent article.

The post-office department of the British empire, not only controls the delivery of all post matter of the realm, but also, as is well known, manages the public telegraph business of the whole country.

The various telegraph companies that operated lines in Great Britain prior to their purchase by the government in 1870, were required to place their wires underground in the city of London, and, since the post-office department has had control of the telegraph, the underground system has been developed until they now claim to have a very efficient and satisfactory system of underground electrical conduits.

Their present system consists of a cable of separately insulated copper conductors enclosed in a cast-iron pipe. This pipe is made expressly for the purpose and is cast in lengths of 9 feet. It has an inside diameter of 3 inches, an external diameter of 4 inches. Inside it is covered with a coating of Dr. Fergus Smith's compound; an insulating material. These pipes are joined together by the ordinary leaded joint used in gas and water mains, and are placed under the sidewalk to the depth of from 12 to 18 inches.

At distances varying from 50 to 200 feet there are manholes or "drawing-in-boxes." These consist of a cast-iron box, without bottom or top, 1 ft. wide, 2 ft. long and 18 inches deep. They are placed on pieces of flagstone of the proper size, and the bottom is made water tight with cement. The cover consists of a cast-iron frame filled with cement and fits tightly over the box, which is put down to such a depth that the cover, when in place, is flush with the surface of the sidewalk. These boxes are placed lengthwise in the line and might be considered merely as an expansion of the pipe at the places where they occur. The pipe enters and leaves in holes at the ends; the joint being made water tight with cement. When branch pipes are necessary they enter the side of the box; the holes for these branches, being made in the boxes as occasion requires.

For conductors No. 18 B. W. G. copper wire is used. This is covered to the diameter of No. 7½ B. W. G. with gutta-percha. It is further protected by a covering of linen tape, and then passed through a bath of hot ozokerite.

The wires thus covered are made into cables of any desired number up to 80 which is the maximum number that the three-inch pipe will hold. Another form, quite recently introduced, is made of four wires separately insulated with gutta percha, and bound together in a cable with ozokerite tape; the interstices between the wires being filled with small tarred rope.

These cables are made in 200 and 400 yard lengths and are placed in the pipe in the following manner: The two ends of one length, which is carefully coiled, are taken to a man-hole near the middle of the section to be occupied by the length. One end is then introduced into the pipe at one end of the box and is pulled through by the aid of a piece of wire previously placed in the pipe. When one-half of the length is thus threaded into the pipe the coil is turned over, and the other half placed in the pipe in the other direction in a similar manner.

In splicing, the wires are first carefully soldered, then the joint is covered with a gutta-percha jacket and separately wrapped with ozokerite tape.

In many of the more important provincial towns the post-office department also controls the telephone service. If the telegraph wires are placed underground in these places, the telephone wires are also placed underground in the same pipes. For this purpose wires prepared similarly to those already described as being used for the telegraph is used. But for the telephone a complete metallic circuit is always used; the return wire being in the same cable with the out wire. Troublesome induction, both between different telephone lines and also between telephone and telegraph lines in the same pipe, is thus effectually prevented as long as the insulation of the telephone wires remains intact.

It may be well to note, *en passant*, that when the government telephone wires are placed overhead, as of course they are excepting inside the village or city limits, a complete metallic circuit in the same cable is always used. The result is that, where the government controls the telephone, an excellent service is given.

When a fault occurs in an underground wire between two "drawing-in-boxes," a new piece of cable of the same number of wires as the one already in the pipe, and of sufficient length to connect the two boxes between which the fault occurs, is looped in at one of the boxes. The cable is then severed between the ends of the loop and the new piece is pulled in place by drawing the defective part out at the other box. The defective part is then looped out, and the line is thus restored without interfering with the circuits, of which the disturbed wires formed a part, for a single instant. One weak point with this system seems to be that in case but one wire of the eighty that may be in the pipe is alone damaged the whole eighty have to be cut out, since there is no system of marking the wires.

In London alone there are 250 miles of this underground pipe in which is laid 10,000 miles of wire. In provincial cities and towns the department owns all told 400 miles of underground pipe, which contains about 9,000 miles of wire.

The pipe used weighs about 100 lbs. per length of 9 feet. The wire weighs 39 lbs. per mile, and the gutta-percha insulation on it, 46 lbs. per mile.

The pipe placed underground and the sidewalks restored costs in London from 5 to 8 shillings per yard, according to the kind of pavement to be moved and replaced. The cable at the present time costs about £13 per mile per complete wire.

Since the wires are being continually disturbed, there is no definite data as to their lifetime, but it is estimated that they could be depended on lasting, on an average, 12 years.

Beside the telegraph wires there is very little underground wire in London. Most of the electric lighting is done on the isolated plant system; there being but one company in London using a central station system, and this company carries its wires overhead.

The wires used by the underground railway are hung in a cable along the walls of their tunnels, and these are the only wires in the tunnels.

The telephone wires in London are all placed overhead. But, judging from their number and from the rarity of finding a telephone in the offices of business men, even in the city proper, their use in this city may be considered in its infancy. The telephone subscribers find a great deal of fault with the telephone service given them, both as to price and efficiency. There is undoubtedly some ground for this feeling, yet, in matters of this kind at least, the average Englishman wants a great deal for his money.

LONDON, December 10, 1885.

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COMMERCIAL EFFICIENCY OF INCANDESCENT LAMPS.

BY CARL HERING.

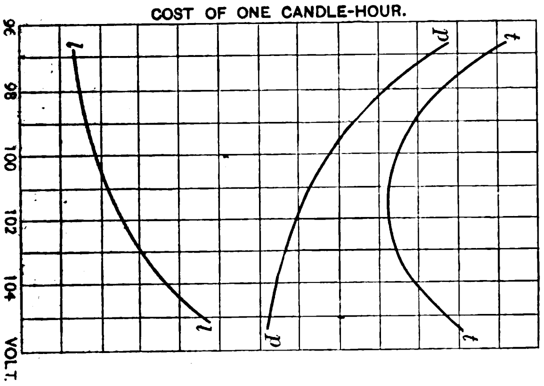
MANY makers of incandescent lamps have found that their lamps upon being measured, have given a much better efficiency (that is, much more light per horse-power) than other lamps in the market, and have used this as an advertisement of their lamp. For a long time, and by many makers, this seems to have been the sole object, that is, to get as much light as possible from a given horse-power. In the tests made by the Board of Examiners at the exhibitions at Paris, Munich and Vienna, and by the first Board of Examiners at the Philadelphia exhibition, this was the only and principal measurement deemed necessary to make of incandescent lamps, and the public was left to judge from the figures obtained, what the relative values of the different systems were.

In the Vienna tests, the lamps were measured with different currents and the corresponding efficiency calculated. These values showed that the efficiency increased very fast with an increased current, in some cases even the candle-power increased with the cube of the electrical energy in the lamp. The very high efficiency of less than one watt per candle was obtained in several cases and tended to show that these lamps were the best. In another case a lamp whose normal candle-power was only about 40 was run as high as 600 candles.

It is evident, however, to any one who has experimented intelligently with incandescent lamps, that there is another factor to be considered, namely the life of the lamp; which as we shall see below, sometimes has as much, and even more weight in the real commercial efficiency than the watts per candle-power. It is a well-known fact that the greater the current the better the efficiency as regards power alone, but at the same time the shorter the life of the lamps; so that many of the lamps which show such a good efficiency, are really poorer lamps than those which give a less efficiency, showing that a test of efficiency by itself is of little or no value, in fact, often misleading, doing injustice to the very lamps which are really the best when the real commercial efficiency is considered, in which, of course, the life of the lamp and its cost are also main factors.

As the cost per candle-power decreases very much with an increased current and as the life of a lamp decreases with an increased current, or what is the same thing, the cost for lamps increases with an increased current,—it is evident that there is some one current or voltage, at which the total cost, considering both lamps and power, is a minimum. This may be shown graphically very nicely, by the adjoining diagram, taken from an excellent article on the subject, by Profs. Ayrton and Perry. The abscissas represent the potential at which the lamps were run, and the ordinates represent the cost.*

COST OF ONE CANDLE-HOUR.



The curve $l\,l$ represents the cost of the lamps themselves, if they are run at different potentials, or what amounts to the same thing, with different currents. This is, of course, dependent upon the life which the lamp has at those different potentials, and the cost of a single lamp. It shows that this cost increases more rapidly as the potential, and therefore the current, increases. The curve $p\,p$ represents the cost of the power required per candle when run at different potentials or current, and shows that it decreases rapidly at first, and less so for greater potentials. As the decrease toward the end of the latter is not as much as the increase in the first curve, it is evident that the sum of the two will fall at first, and rise again toward the end, showing that at a certain point there will be a minimum cost. This is shown by the third curve $t\,t$ which represents the total cost or the sum of the two others. As will be seen this becomes a minimum at a certain point, which for the particular lamp from which the data was taken, is about 102 volts, or thereabout. This, as is seen, is determined theoretically to a certain extent, while, if the writer is correct in the particular make of lamp which he assumes was used, the manufacturer found about the same result in a purely practical way by running the lamps at different potentials and finding their life, from which they determined the proper potential at which they should run their lamps.

From what was said above it is very evident that in order to determine the real relative values of different lamps to the consumer, their life and the cost of a lamp must be taken into consideration besides the efficiency. The real values of different systems of lamps to the consumer also depends greatly on the way in which the lamps and installations are made, that is whether the lamps are liable to fail at the connection between the platinum wires and the filament; what the durability of the filament is, as regards mechanical strength; the nature of the holder, that is whether the contacts between the lamp and holder are good, firm and not liable to heat; also the price and nature of holder, etc., etc. But it is evident that such factors cannot possibly be brought into any general calculation or formula, and will have to be left to the buyer to judge upon, or to an electrical engineer who is consulted.

To reduce the first mentioned qualities to a form in which different lamps may be compared, the following formulæ may readily be deduced:

Let C represent the cost in cents, of one spherical candle-power per hour.

e the efficiency in watts per spherical candle-power, of the lamp at its normal candle-power.

P the price, in cents, of one electrical horse-power per hour in the lamp.

p the price of a lamp in cents.

L the life in hours, of a lamp at its normal candle-power.

c the normal spherical candle-power of a lamp.

Then the cost of one candle-power hour, as far as the efficiency is concerned, is the horse-power consumed multiplied by the price of one horse-power, that is,

$$C = \frac{e}{746} P$$

The cost of one candle-power hour, as far as life is concerned, is the price of a lamp divided by the candle-power hours which the lamp is capable of giving, which latter is evidently the life multiplied by its spherical candle-power. This gives

$$C = \frac{p}{L \times c}$$

The total cost in cents, of one spherical candle-power is, therefore, the sum of these two expressions, that is

$$C = \frac{e\,P}{746} + \frac{p}{L \times c}$$

The only reliable data which can be used justly in making any relative comparisons of different lamps by means of this formula are the results of the excellent and thorough tests made by a special committee under the auspices of the Franklin Institute in the spring of 1885. They are the only impartial tests made of incandescent lamps

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of different systems which give the life and efficiency of different lamps at their normal candle-power. It is very unfortunate that one of the principal electric light companies in this country, had such a misfortune in regard to the lamps delivered to the test committee. It is very much to be regretted, as the tests of this lamp were looked upon with special interest. The results of this lamp, the Weston, in the following comparisons, cannot therefore be justly compared with the others. If however, this company guarantees a certain life at the same efficiency obtained in the test, the comparison can be justly made with the others.

From the report of these tests, we find the average efficiency of the lamps of each of the different systems in watts per spherical candle-power to be as follows :

Edison,	4.459
Stanley 96 volts,	4.04
Stanley 44 volts,	3.544
Woodhouse & Rawson, 1st lot,	3.605
Woodhouse & Rawson, 2d lot,	3.56
White,	4.05
Weston 110½ volts,	3.713
Weston 70 volts,	4.51

In order to obtain the real average life of all the lamps used, it would have been necessary to run them all until they died, but as this was not done it will be impossible for us to get the real life from the tests. In order, therefore, to make any relative comparisons from them, it is necessary to make some assumptions in regard to the death of the surviving lamps. Although such assumptions may not be quite correct they will be at least approximately so, and will enable us to make a comparison which will, at least, give tolerably fair results.

As most of the lamps which survived have a discoloration of at least two and one-half, and many of them three to four, in a scale of six, it will not be far wrong to assume that those lamps died at the end of the test. This is a wrong assumption, but we have no right to assume a certain life for these lamps, as that would be different for different systems, nor have we a right to take only those lamps which died before the end of the test. This assumption will however give results which are within the limit which would be obtained if we knew the real life, that is, the real ultimate cost will not be more than the results obtained.

It will furthermore be seen from the test that the candle-power decreases very materially in most lamps, and by taking the efficiency at the beginning of the test, the error may be left to compensate, to a certain extent, the incorrect assumption that they died at the end of the test. At all events it will not be giving any lamp any undue credit to make the first assumption, and if with the final results it is remembered that a certain number survived and would have increased the life accordingly, and therefore decreased the ultimate cost slightly, it will enable one to make at least a rough comparison of the different systems. Although the results obtained thus give only rough values, it is easily seen that unless some such assumption were made, no relative results could be obtained from the tests.

Making this assumption, the average life of each of the different systems of lamps are as follows :

Edison,	1,026 hours.
Stanley 96 volts,	430 hours.
Stanley 44 volts,	293 hours.
Woodhouse & Rawson, 1st lot,	290 hours.
Woodhouse & Rawson, 2d lot,	267 hours.
White,	273 hours.
Weston 110½ volts,	507 hours.
Weston 70 volts,	461 hours.

Another assumption can be made, which may be nearer the real result, though at the same time it may give undue credit to some of the systems. At the end of the test the lamps were examined in regard to their discoloration and marked with a scale of six units, of which number six was quite dark, totally unfitting the lamp for use if it was burning. To assume therefore that a lamp with a discoloration of five was practically dead, will not be very incorrect. It is also quite fair to suppose that the discoloration increases directly as the number of hours which the lamp burns. From this it can readily be calculated from the data of the tests at what age the survived lamps would have had a discoloration of five on the adopted scale of six units, and to consider the lamp practically dead then.

Making this assumption and calculation the average life of all the lamps of each system gives :

Edison,	2,038 hours.
Stanley 96 volts,	501 hours.
Stanley 44 volts,	319 hours.
Woodhouse & Rawson, 2d lot,	305 hours.
White,	407 hours.
Weston 110½ volts.	1,022 hours.
Weston 70 volts,	1,012 hours.

The price of a lamp to a consumer of a 100-light plant, given to the writer by the different companies, is as follows :

Edison,	85 cents.
Stanley 96 volts,	70 to 75 cents.
Stanley 44 volts,	70 to 75 cents.
Woodhouse & Rawson,	120 cents.
White,	100 cents.
Weston 110½ volts,	85 cents.
Weston 70 volts,	85 cents.

The Stanley company not having been heard from, the price of that lamp was taken as given by the Van Depoele company, who use that lamp. They gave the price for a 100 volt lamp ; the writer assumed the same price for the 44 volt lamp. As the writer could not find out the cost of the Woodhouse & Rawson lamp, the price assumed was that at which the lamps were offered in large quantities to the writer, in London, about a year ago, namely five shillings, their great efficiency being offered by the makers as an explanation for their high price.

Assume the cost of a mechanical horse-power per hour as applied to the pulley of a dynamo, including coal, attendance, shafting, etc. to be four cents, and that the commercial efficiency of the dynamo (that is, the ratio of the electrical power in the external circuit to the mechanical power applied at the belt) is 88 per cent., and that five per cent. is lost in the leads. This makes the cost in cents, of an electrical horse-power in the lamp.

$$P = \frac{4}{.88 \times .95} = 4.8 \text{ cents.}$$

Introducing all these values together with those given above into our equations, calculating the cost of the power from the efficiency in watts per candle-power, and the cost due to the life from each of the above assumptions, gives the results in the following table.

Column i is the cost of a lamp as given by the respective companies, with the above mentioned exception. Columns ii and iii are taken directly from the report. Column iv, calculated with our formula is dependent only on the efficiencies in column iii, and on the cost of a horse-power. Columns v and x are calculated from the results of the tests assuming that the survived lamp died as above explained. Columns vi and xi are calculated with our formula from columns v and x, each combined with columns i and ii. Columns vii and xii are the sums of column iv with columns vi and xi respectively, and are the ultimate results which interest the consumer. Columns viii, ix, xiii and xiv are of interest to the manufacturer, showing how much of the total cost is due to the efficiency, that is, the power, and how much is due to the life and the cost of the lamp. Column xv is the relative commercial rank of the different lamps as obtained from the results in column xii. It will be noticed that this is the same, in the case of the Weston lamp whether the life, as given by the test, is taken, or whether the guaranteed life of 1,000 hours is taken.

As mentioned above, the Weston lamps used in the tests

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were unfortunately from a poor lot, and are not as good as their average lamps; they were therefore pronounced useless by that company. The writer was informed by that company that they guaranteed their lamps to have a life of

Name of lamp.	i. Cost, in cents, of a single lamp.	ii. Mean spherical candle-power at beginning of test.	iii. Efficiency in watts per spherical candle-power.	iv. Cost, in cents, of power for 1 spherical candle-power hour.	v. Average life in hours. (Assuming survived lamps to have died at end of test.)	vi. Cost, in cents, of lamp for 1 spher. c.-p. hour.	vii. Total cost, in cents, for 1 spher. c.-p. hour.	viii. % of cost for power.	ix. % of cost for lamp.	x. Average life in hours. (Assuming survived lamps to have died when their discoloration would have been 5.)	xi. Cost, in cents, of lamp for 1 spher. c.-p. hour.	xii. Total cost, in cents, for 1 spher. c.-p. hour.	xiii. % of cost for power.	xiv. % of cost for lamp.	xv. Relative commercial rank of lamps from column xii.
Edison	85	15.47	4.459	.0287	1026	.0054	.0341	84	16	2038	.0026	.0313	92	8	2
Stanley 96 volt	70	18.59	4.04	.0260	430	.0120	.0380	68	32	501	.0103	.0363	72	28	4
Stanley 44 volt	70	18.42	3.544	.0228	298	.0177	.0405	56	44	319	.0168	.0391	58	42	5
Woodhouse & Rawson, 1st lot	120	15.64	3.605	.0232	290	.0264	.0496	47	53						
Woodhouse & Rawson, 2d lot	120	18.80	3.56	.0229	267	.0246	.0475	48	52	305	.0215	.0444	52	48	6
White	100	12.44	4.05	.0261	273	.0294	.0555	47	53	407	.0197	.0458	57	43	7
Weston 110½ volt	85	16.48	3.718	.0238	507	.0102	.0340	70	30	1022	.0051	.0289	82	18	1
Weston 70 volt	85	15.18	4.51	.0290	401	.0121	.0411	71	29	1012	.0055	.0345	84	16	3
Weston 110½ volt	85	16.48	3.718	.0238	600*	.0086	.0324	73	27	1000*	.0052	.0290	82	18	(1)
Weston 70 volt	85	15.18	4.51	.0290	600*	.0098	.0388	76	24	1000*	.0056	.0346	84	16	(3)

*Guaranteed life.

from 600 to 1,000 hours, depending on the nature of the installation, that is, whether the engine runs steadily, etc. The last two lines in the table were therefore calculated with this assumed life, and give the figures which can be justly compared with the rest. It will be noticed however that no matter whether the figures in column vii or xii are taken, or whether the life, as given by the test or as guaranteed, are taken, the Weston high tension lamp is still the most economical, with the assumed cost of a horse-power hour four cents. If the price is more than that, which it will be in many installations, the results will be still more in favor of the good efficiency lamps (see column iii).

The way the results will be affected by a different cost of the power than that assumed, will easily be seen from the table. A higher cost of a mechanical horse-power hour than four cents will decrease the relative ultimate costs for the high efficiency lamps, such as the Stanley 44 volt, the Woodhouse & Rawson and the Weston 110½ volt; while it will increase the relative ultimate costs for the poor efficiency lamps such as the others.

It will also be noticed from the table, columns viii, ix, xiii, xiv, that those lamps in which the cost for the power is a large proportion of the total cost, the life and cost of a lamp play but a small part in the whole cost, and that increasing the life will be of comparatively little value. But if in these lamps the efficiency be increased at the expense of the life, it will be a decided advantage. From the figures for the Edison lamps it will be seen that increasing the life from about 1,000 hours to 2,000 hours decreases the ultimate cost only about eight per cent.

Of the two assumptions made to determine the average life of the lamps, column v gives undoubtedly too low results while in column x they are probably slightly too high, as many of the dead lamps have a discoloration of less than five on the scale, and it is probable that the survived lamps would not have lived until their discoloration was five. The real values of the ultimate cost will, therefore, no doubt be lower than the figures in column vii and higher than those in column xii. But by comparing these last two columns it will be seen that the relative values for the different lamps are not changed very much, in fact, leaving out the low voltage lamps (Weston 70 volt and Stanley 44 volt), which the writer believes are seldom used, the relative rank remains the same whether the results in column vii or xii are taken. Therefore, although the necessary assumptions made to determine the life of the survived lamps, are from their nature not absolutely correct, they show that for two extreme cases the relative values are not changed, and therefore the real relative values which lie between the extremes will be the same.

The writer wishes furthermore to call attention to the fact, that in the above calculations and comparisons there is no "personal" factor, the results being obtained from figures only, and can be calculated by any one from the results of the tests of the Franklin Institute.

ON THE METERS OF PROFESSORS AYRTON AND PERRY.

BY GEO. B. PRESCOTT, JR.

Everyone who has anything to do with the running of arc or incandescent lamps, realizes the necessity of using some sort of current and potential indicators or measurers, to insure uniform and satisfactory working. The portability and simplicity of Professors Ayrton and Perry's voltmeters and ammeters have recommended them to practical men, and they are now extensively employed in commercial electric lighting. Although it is more or less well-known that the moment of the permanent magnets in these instruments is subject to change, and that the value of their constants is thereby altered, but few of the actual users are aware of the extent of this variation. Even less known is the fact that the heating of the coils, particularly in the voltmeters, is another serious source of error, whilst the circumstance that in these meters a division of the scale near the zero end represents a much greater variation, in potential or current as the case may be, than a division near the other end, is almost entirely overlooked. It is evident that an instrument containing so many defects must be handled with judgment to obtain even approximately correct results, and to supply the necessary information on which to base such judgment is the object of this article. I should not consider it needful, however, if there was a more reliable and equally cheap and convenient substitute for these instruments on the market.

The results of careful tests of a large number of Ayrton and Perry's voltmeters and ammeters, extending over a period of nearly three years, may be summed up as follows:

The permanent magnets gradually grow weaker, reducing the value of the constant.

The change is more rapid in new instruments than in old ones.

The change is more rapid in instruments which are used frequently than in those seldom used.

The change is modified by stronger magnets, such as dynamos.

The percentage change in the value of the constant is different in several instruments under apparently the same conditions.

The error due to heating of the coils is very noticeable

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in the ammeters, and seriously affects the voltmeters, increasing the value of the constant in both cases.

The difference in the value of a scale division at 0° and at 45° varies from 10 to 20 per cent. in different instruments.

For the same instrument a change in the strength of the permanent magnet does not alter the above percentage.

The information supplied by these facts leads to the conclusion that to obtain satisfactory results from these instruments the following conditions should be observed :

Their constants should be frequently determined.

They should be calibrated at the current strength and potential at which they are to be used.

The voltmeter readings should be taken immediately after the needle comes to rest, and the circuit then broken. The readings should not be taken so frequently as to heat the coils.

Experience has shown that with wire of the size commonly used, the resistance of the voltmeters should not be less than 50 ohms for each volt to be measured. The wire in the ammeters should be sufficiently large to carry without appreciable heating at least double the current to be measured. They should be calibrated as often as once a fortnight to once in three months, according as they are new and much used or old and little used.

Selected according to the above specifications, and used with the precautions suggested, these ammeters and voltmeters may be made to yield results sufficiently reliable for most commercial work.

It may be asked, "How are these instruments to be calibrated?" To that question I must reply that it is not within the province of this article to describe the various methods of calibration, as these are fully explained in the text books, but, undoubtedly, such work can only be well and conveniently done when certain facilities, not possessed by every user of ammeters and voltmeters, are at hand. For such as have not the requisite facilities the best plan is to take their instruments to those who have. In this connection I may mention that the licensees of the United States Electric Lighting Company send their instruments to Mr. Weston's laboratory where, for a small fee, they are carefully standardized, and I have no doubt that others who choose to do so may avail themselves of the same privilege.

WESTON LABORATORY, Newark N. J., Dec. 23, 1885.

ELECTRIC TRANSMISSION OF POWER AT CREIL.

THE experiments of M. Marcel Deprez at Creil, have at length assumed a somewhat practical form. The dynamos are completed, and were put in place on the 20th of October, when M. Deprez made some preliminary tests of the plant in presence of a commission consisting of MM. Collignon, inspector-general des Ponts et Chaussees ; Delebecque, ingenieur en Chef du Materiel et de la Traction, of the Northern railway of France ; Contanini, engineer in the same company, and others. The generating dynamos made by MM. Breguet, and the receiving dynamos constructed by MM. Mignon and Rouart, were, during the preliminary trial, placed side by side, one portion of the circuit being very short, and the other twice the distance between La Chapelle and Creil, or 70 miles. In future experiments, the two dynamos will be placed in their normal positions at the respective termini of the line. The generating machine is driven by a portable steam engine ; the resistance of its field magnets is 5.68 ohms, and of the two armatures 33 ohms. The resistance of the two armatures of the receiving machine is 36.8 ohms, and the resistance of the line is 97 ohms ; the field magnets of the generator and receiver are each excited by a separate machine. Five different trials were made at varying speeds of the driving shaft ; the initial work on this shaft was measured by a dynamometer. The available energy delivered on the shaft of the receiving machine was determined by a Prony brake ; the remaining results of the experiments as hereinafter given were deduced from the constants of the machines, and from galvanometric measurements. For the first trials the different elements were as follows :

1. *Generating Dynamos:*
   - Speed of armature..................123 revolutions.
   - Difference of potential at terminals....3370.25 volts.
   - Electromotive force (total)..............3624.7 volts.
   - Available work at driving shaft.............43 h. p.
   - Electrical work of generator......................37.38 h. p.
   - Difference absorbed.........................5.62 h. p.
2. *Line:*
   - Energy lost in the line conductors..........7.59 h. p.
3. *Receiving Dynamos or Motors:*
   - Speed of armature...................154 revolutions.
   - Difference of potential at terminals.....2616.25 volts.
   - Difference of potential (actual)........2336.94 volts.
   - Electrical work of motor..................24.10 h. p.
   - Available work given out at shaft.........22.10 h. p.
   - Difference absorbed..........................2 h. p.

The duty obtained would thus be $\frac{22.10}{43} = 51.3$ per ct. if the work absorbed by the exciting machines be not considered. Taking this into account, it would be reduced to 40 per cent.

In subsequent experiments the speed of the generator was gradually increased. In the last trial the following were the elements :

1. *Generating Dynamos:*
   - Speed of armature...................190 revolutions.
   - Difference of potential at terminals.....5231.25 volts.
   - Electromotive force (total)............5469.75 volts.
   - Available work at driving shaft..............62 h. p.
   - Electrical work of generator..............53.59 h. p.
   - Difference absorbed...........................8.51 h. p.
   - Work absorbed by armature...............2.33 h. p.
2. *Line:*
   - Energy lost in line conductors.............7.21 h. p.
3. *Receiving Dynamo or Motor:*
   - Speed of armature.....................248 revolutions.
   - Difference of potential at terminals........4508 volts.
   - Difference of potential (actual)........4242.67 volts.
   - Electrical work of motor.................41.44 h. p.
   - Work measured on shaft of motor...........35.8 h. p.
   - Difference absorbed............................5.64 h. p.
   - Duty obtained (not including exciting machine) 57 per ct.
   - Duty obtained (including exciting machine) 48 per ct.

During the different experiments the current traversing the line varied from 7.59 ampères to 7.21 ampères. No heating of any kind was observed.

M. J. Bertrand, has communicated a paper to the Academy of Sciences on the subject, in which he comments upon the relatively low speeds. It corresponds to an angular displacement of the surface of the armatures which in no case exceeds the ordinary speed of a locomotive wheel. The potential reached 5500 volts., with a current that in no way endangered the line. This first experiment is at all events, encouraging, and is to be followed by others of a more complete and exhaustive character. MM. de Rothschild are now organizing a commission of able French and foreign scientists, who will investigate the subject carefully, and will hereafter report upon it.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

A GENERAL meeting of the Institute was held at the house of the American Society of Civil Engineers on December 8, for the purpose of amending the by-laws which were not wholly satisfactory. One of the features of the original rules which caused considerable misunderstanding, was the distinction between members and associate members. While both classes have been entitled to equal privileges there has been an apparent tendency toward acquiring full membership without the attainment of proper qualifications. This has now been remedied by restricting the elective powers of the council to associate membership only, subsequent applications for transfer to membership being made to a special board of examiners, whose office it is to determine whether the applicants are sufficiently versed in electrical science to be properly classified as members.

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COMPETITIVE TESTS OF DYNAMO ELECTRIC MACHINES.

REPORT OF THE FRANKLIN INSTITUTE COMMITTEE.

To the Board of Managers of the Franklin Institute.

(*Concluded from page* 457, *vol.* iv.)

POWER MEASUREMENTS.

The general principle of the Tatham dynamometer is shown in figure 7. The power applied to the shaft on which the driving pulley D is fixed, is transmitted to the pulley B, to whose shaft the machine to be tested is coupled, by an endless belt, which passes over D, under the stretching pulley S, over the weighing pulley W, under B, over the second weighing pulley W, under S, back to the place of starting. Each of the weighing pulleys W is supported in a cradle, the outer end of which is pivoted on the knife edge F, while the inner end is supported by the link L C. The upper ends of the two links are fastened to the scale beam F, P at equal distances from and on either side of the fulcrum F.

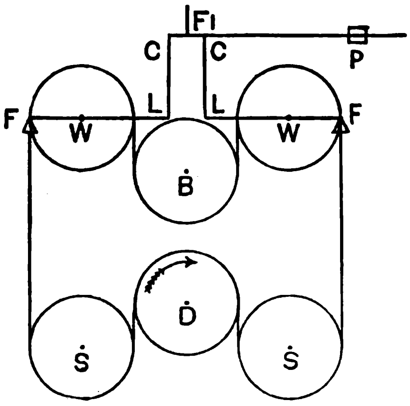

FIGURE 7.

To calculate the power applied to the pulley B, it is necessary to know three things: The difference of tension of the belt on the two sides of B; its effective diameter, and its number of revolutions. These will be discussed in order.

The scale beam is acted upon through the links L C, fastened to the cradles of the weighing pulleys W. The tensions of the belt on the outer faces of these pulleys have no effect on the beam, since the line of effort of the belt passes through the knife edges F. The only forces then that act on the beam are the two tensions of the belt on the inner faces of the pulleys W, *and these are the tensions on the two sides of* B; and the links being at equal distances on either side of F, the *difference of the tensions* is recorded on the beam.

The scale beam was of steel, graduated by Brown and Sharpe into 600 divisions. With the weight used each division meant one-half pound. A small poise traveling on the weight allowed readings to be taken to $\frac{1}{100}$ of a pound. There were two adjustments to the cradles. In the first, the axis of the pulley W was moved by micrometer screws to such a position that the line of effort of the belt passed through the knife edges of the cradle. To show this, the pulley was chocked, a short piece of the belting hung on its outside face, and weights placed in a pan hanging to the belt. When there was no effect on the scale beam, the adjustment was accomplished.

The second adjustment determined the position of the knife edge to which the links were connected. This was moved until the beam weighed about 250 pounds correctly to within one-twentieth of a pound.

The pulley B was calculated to deliver 6.6 feet per revolution, but the belting used was thicker than was at first intended, and the value 6.6 should be increased by one-fourth per cent. The effective diameter of the pulley, including the thickness of the belt, was measured directly, and also calculated from the length of belt delivered by five turns of the pulley. For the latter measurement, two steel points, one of which was fitted with a micrometer screw, were fixed on a wooden rule, and their distance apart accurately determined on a standard scale. Marks were made on both the pulley and belt opposite to fixed pointers. Five revolutions were given the pulley, and the length of belt that passed the pointer was measured by the rule with the steel points, any margin being taken off by a pair of compasses. The pulley was turned both ways and the effect of stretching eliminated.

The two methods checked very closely, and gave for the delivery of the pulley

6.6 (1.0025) feet per revolution.

A very ingenious mechanical counter registered the number of revolutions. Observations could be taken each minute, and the counter recorded continuously to 1,000,000 revolutions.

Having the difference of tension on the two sides of B, its delivery per turn, and number of turns per minute, the horse-power is calculated as follows:

$$\text{H. p.} = \text{divs. scale beam} \times \text{no. revs.} \times \frac{6.6\ (1.0025)}{2 \times 33000}$$

$$\text{H. p.} = 1.0025 \left\{ \frac{\text{divs. scale beam} \times \text{no. turns per min.}}{10{,}000} \right\}$$

It will be seen that the only part of the friction of the dynamometer that appears in the readings, is that due to the bearings of the pulley B. By the principle of Morin, that the sum of the tensions on the two parts of a belt is constant, this friction should be the same whatever the load. In getting the power applied to a machine, after the measurements have been made with the machine coupled to the dynamometer, it was uncoupled and the dynamometer run at the same number of revolutions, the scale beam observed, and its reading subtracted from the reading when coupled.

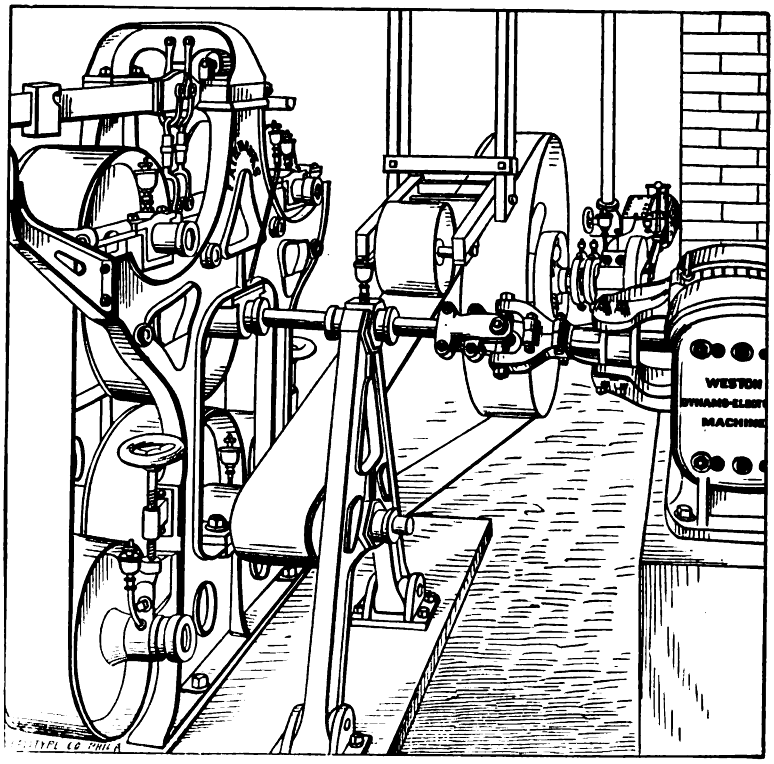

FIGURE 8.—Universal Coupling.

To avoid the uncertainty of loss due to belting, the shaft of the driven pulley B was coupled directly to the dynamo by a universal coupling, as shown in figure 8. It was assumed that this would allow for any slight inexactitude in lining the dynamo and dynamometer shafts, but it is doubtful if it was of much value at the high speeds used for the tests.

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The figure of the dynamometer, figure 9, gives a view of it as used in these tests. The automatic recorder for the scale beam, shown in the figure, was not used. In making observations, the number of revolutions and scale beam were read each minute, usually for 10 minutes. The means of the two sets were multiplied together, the product divided by 10,000, and a correction of one-fourth per cent. applied, as given in the formula.

The delicacy and range of the dynamometer were both very great. On one occasion the power absorbed by a single Weston mammoth lamp was accurately measured, while the slightest variation of the load could be at once detec-

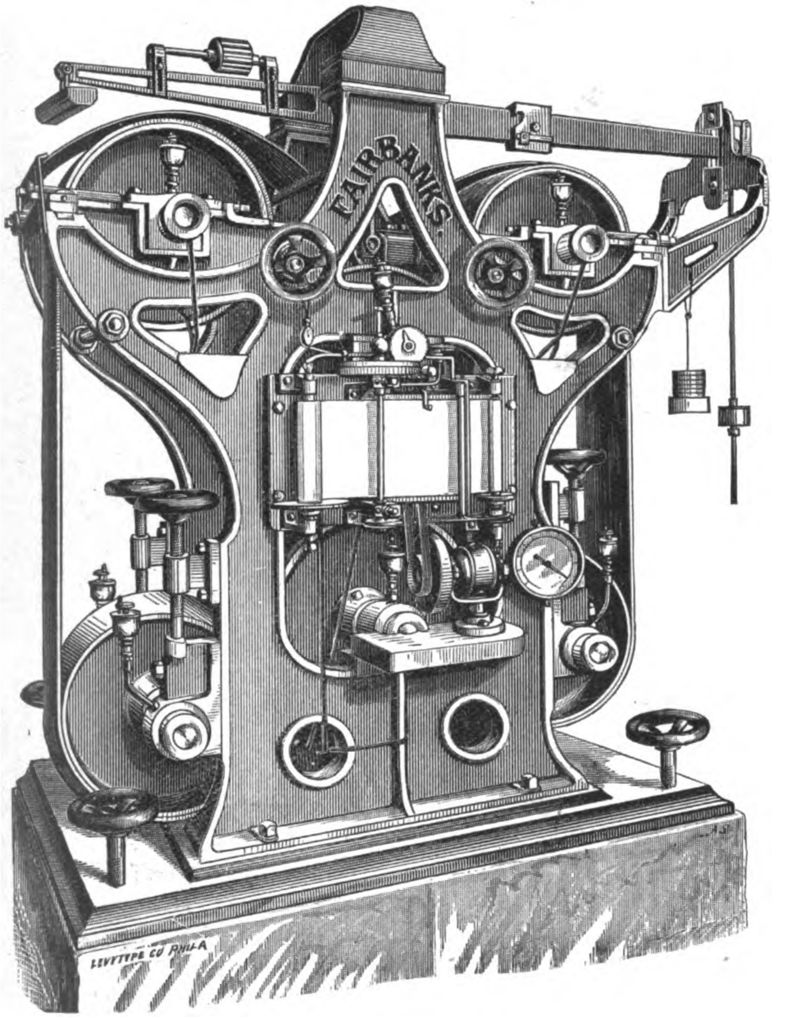

FIGURE 9.

ted. During a test, the scale beam usually floated steadily, the slight and rapid jar caused by running served to limber up the weighing apparatus and render it especially sensitive. Indeed, it would be hard to fix a limit to the accuracy with which the observations could be taken.

Mr. Tatham has published a paper[1] giving the principles involved in the dynamometer, and describing its various modifications of form.

The engine used was a 10″ x 20″ Salem Buckeye. Its governor adjustment could be readily varied from 100 to 200 revolutions. The speed, under the steady load of a dynamo, was very uniform.

A steel boiler, loaned by the Baldwin Locomotive Works, was used. It could safely carry 150 pounds per square inch and develop 80 h. p.

CHECKING THE DYNAMOMETER.

In order to make the tests absolutely, as well as relatively accurate, it was decided to check the work recorded by the dynamometer against an amount of work calculated from the mechanical equivalent of heat.

To do this, a calorimeter was constructed, the general plan of which is shown in side and end section in figures 10 and 11.

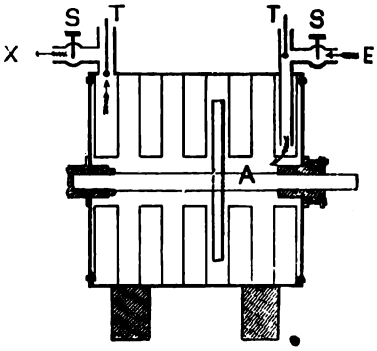

FIGURE 10.

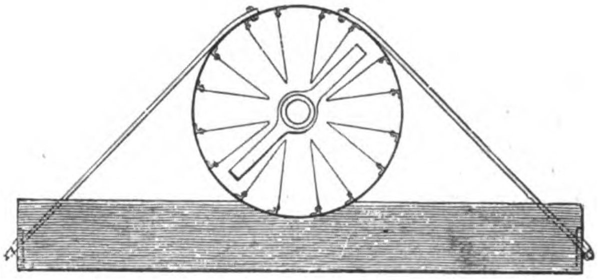

FIGURE 11.

It was of wrought iron, three feet long by three feet in diameter, with V-shaped projections riveted inside the shell. The paddles 30 inches long by one-half inch thick, were keyed to the shaft and moved between the V's. One end of the shaft passed through the end of the calorimeter, and was coupled to the dynamometer. In the experiments but one paddle was used, 700 revolutions absorbing about 45 h. p.

Two different methods of experiment were employed; first with a constant weight of water and an increasing temperature; and second with a constant temperature and a continuous flow of water through the calorimeter.

First Method.—In the first method the calorimeter was filled and its water equivalent found, the engine was then started, and the rise of temperature noted and the dynamometer observed. The mechanical equivalent was calculated from the work recorded by the dynamometer, the water equivalent of the calorimeter and the rise of temperature, the necessary corrections being applied to the latter. The value thus obtained was compared with the values of Joule and Rowland.

In getting the water equivalent, the calorimeter was first weighed empty and then when filled with water. The difference gave the weight of the water, and the water equivalent of the iron was calculated from its weight and specific heat. It was intended to determine by experiment the specific heat of the specimens of the iron used in the calorimeter, but circumstances made this impossible. The value used,

.112,

is taken from determinations by Bystrom, Weinhold, Regnault and Bede, reduced to 30° C. The values given by these different experimenters agree very well, and it seems probable that the mean does not differ from the specific heat of the iron used in the calorimeter by more than one or two per cent. at the most—an error that enters as about one-tenth in the result.

The weighings were made with a scale beam by Fairbanks. Both the weights and graduation had been tested.

1. *Journal Franklin Institute*, Dec., 1882. Vol. cxiv.

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The following are the results obtained :

Weight of calorimeter alone	1228.75 pounds.
Weight of calorimeter with water,	2451.75 pounds.
Weight of water,	1223.0 pounds.
Water equivalent of the iron,	137.62 pounds.
Total water equivalent,	1360.62 pounds.
Correction for weighing in air,	1.38 pounds.
Water equivalent, corrected,	1362.00 pounds.

Temperature Observations.—The thermometers used were those by Green, already described. The time the mercury crossed each half degree was observed and was taken as the mean of the times of crossing the tenths below and above the division, and the division itself. The times were noted by a chronometer.

The following table gives the temperature observations and the dynamometer readings,—the latter were taken each minute :

CALORIMETER OBSERVATIONS FOR CHECKING DYNAMOMETER, June 27.

TEMPERATURE.	Observed time of crossing division.	Corrected time of crossing division.	Intervals for 4.5° C.	REMARKS.
30.5	12-01-44.	12-01-44.		The times were corrected arbitrarily by the observations on either side.
31.	02-20.3	02-20.3		
31.5	02-57.0	02-56.8		
32.	03-33.3	03-33.3		
32.5	04-09.6	04-09.7		
33.	04-46.0	04-46.3		
33.5	05-22.3	05-23.1		
34.	06- 1.6*	06-00.2		
34.5	06-37.6	06-37.3		
35.	07-14.0	07-14.4	5-30.4	
35.5	07-51.6	07-51.6	5-31.3	
36.	08-29.0	08-29.0	5-32.2	
36.5	09-07.3	09-06.2	5-32.9	
37.	09-43.3	09-43.4	5-33.7	
37.5	10-20.3	10-20.6	5-34.3	
38.	10-58.0	10-58.0	5-34.9	
38.5	11-36.0	11-35.5	5-35.3	
39.	12-13.0	12-13.0	5-35.7	

*Untrustworthy, only one reading.

DYNAMOMETER READINGS.

TIME.	Counter.	Scale Beam.	Friction.	REMARKS.
12-01-00	0159			
02-00	0881	665	13.72	
03-00	1603	666	13.72	
04-00	2326	664	13.72	
05-00	3042	661	13.72	
06-00	3161	661	13.72	
07-00	4479	661	13.72	
08-00	5198	663	13.72	
09-00	5916	666	13.72	
10-00	6640	666	13.72	
11-00	7360	666	13.72	
Mean:	720.1	663.9	13.72	

The corrections to be applied to the thermometer readings are for the part of the stem in the air, and for radiation. The first of these is somewhat indefinite, as a portion of the stem is heated by conduction from the calorimeter. The whole correction, however, is only about one-third per cent., and its value is probably correct within 20 or 30 per cent. so the error in the result from this cause can hardly be much over one-tenth per cent.

But the most important correction, and the one in which there seems the greatest possibility of error, is the co-efficient of radiation. This is usually determined by slowly stirring the calorimeter, and noting its difference of temperature from the air and rate of cooling, correcting for the heat developed in stirring. But with a single thin blade, and no arrangement for causing circulation, this method was impracticable. In some experiments that were tried, the water was not thoroughly mixed, and the cool water falling and warm water coming to the top, made the values obtained worthless.

Under these circumstances, it became necessary to calculate the radiation from the experiment for the determination of the mechanical equivalent.

The method of calculation was as follows : The observations were divided into intervals of 4.5° C., as shown in the following table, and the corresponding intervals of time were reduced to the same rate of doing work, the same value of the specific heat of water, and the same value for the stem correction of the thermometer. The remaining difference in the intervals is assumed to be due to radiation.

CALCULATION OF RADIATION.

INTERVAL.	Time interval uncorrected.	Ratio of rate of doing work to mean rate.	Correction for specific heat of water.*	Correction for stem in air.*	Time interval corrected.	Excess over first interval.
degrees.	minutes.	×	+	+	minutes.	minutes.
30.5—35	5.5067	1.00145	1.00000	1.00000	5.51467	.00000
31. —35.5	5.5217	1.00026	1.00000	1.00016	5.52224	.00757
31.5—36	5.5367	.99957	1.00010	1.00032	5.53200	.01733
32. —36.5	5.5483	.99885	1.00020	1.00048	5.54196	.02729
32.5—37	5.5617	.99847	1.00031	1.00065	5.54808	.03341
33. —37.5	5.5717	.99824	1.00040	1.00081	5.55530	.04063
33.5—38.0	5.5817	.99980	1.00050	1.00097	5.57250	.05783
34. —38.5	5.5883	1.00134	1.00060	1.00113	5.58607	.07140
34.5—39	5.5950	1.00219	1.00070	1.00130	5.59600	.08133

Gives radiation .00258° per degree per minute.
*These are the ratios of each succeeding interval to the first interval.

The differences of these corrected intervals from the first interval were plotted, the excess of the mean temperatures of the intervals over that of the air being taken as abscissæ, and the above differences as ordinates. A straight line was drawn through the points thus found. The radiation was calculated by taking the difference of the ordinates for an interval of 4°, and from this value (which is the loss of time due to radiation, in an interval of about 5.55 minutes, the difference of temperature being 4°) the coefficient of radiation was easily found.

In drawing a straight line through the points, we have assumed the coefficient of radiation to be constant when the excess of temperature over that of the air varies, instead of increasing with the excess. Within the rather narrow limits of temperature used, however, the value found represents very nearly the radiation for the mean interval. In calculating the experiment by the second method, the value of the radiation found above was corrected to the greater difference of temperature between the calorimeter and air, by increasing it in the ratio shown by the experiments of McFarlane and Rowland.

This method of calculating the radiation, while not so accurate as the method usually employed, has the advantage that the conditions of observation are accurately those of the experiment to which the radiation is applied.

It will be seen that the errors likely to affect the radiation coefficient, are errors of observation, in the relative values of the specific heat of water at the different temperatures, and in the ratios of the stem corrections.

As for errors of observation, the dynamometer readings for the intervals were the mean of five observations, and, although the jar interfered somewhat with the readings of the thermometer, yet the table shows that there were no very great errors, and the method of observation allowed the readings to be to some extent corrected by those on either side.

The ratios of the values of the specific heat of water for the different intervals were calculated from Rowland's values of the mechanical equivalent for the mean temperatures of the intervals. Fortunately the correction was small, and probably accurately given.

Whatever the absolute value of the stem correction might have been, there could be little error in the relative values for the different intervals.

The result obtained was :

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Excess of cal. over air, 4° C. coefficient of radiation, .00258
8° C. .00262

On applying the above values to the observation by the first method, we obtain:

Mean rise of temp., per min. (uncorrected)	.809814
Mean correction for radiation,	+ .017790
Mean correction for stem,	+ .003034
Mean correction to absolute temperature,	— .001350
Mean rise, per minute (corrected),	.822288
Water equivalent of calorimeter,	1362.0 pounds.
Heat units developed per minute,	1119.9562
Mean reading scale beam,	663.9
Friction reading scale beam,	13.72
Difference reading scale beam,	650.18
Mean revolutions,	720.1
Work in foot pounds = prod. × 3.3 × 1.0025	15489048
Mechanical equivalent for 1° C.,	1383.01 ft. lbs.
Mechanical equivalent for 1° F.,	768.34 ft. lbs.

Unfortunately, however, the construction of the calorimeter made the results of this experiment untrustworthy. The blades were kept apart by pieces of four inch pipe, one-eighth inch thick, fitting over the shaft between them. In the space between the shaft and pipe were about five pounds of water not in circulation with the mass in the calorimeter. The shaft being jacketted with this layer of water, must have gained heat but slowly. The result was that the heat units calculated were too great, and the mechanical equivalent too small. It is also probable that this effect would make the coefficient of radiation calculated from this experiment slightly too large.

We can only say of this experiment then that the value is 768.3 + an indeterminate correction.

Second Method.—In this method water was made to flow continuously through the calorimeter. The engine was run until the temperature of the exit water ceased to rise, and then observations of the entrance and exit temperatures and of the dynamometer were taken each minute, and the exit water weighed every four minutes. The weighings were made by two of Fairbanks's platform scales that had been tested with standard weights. The observations lasted one and one-half hours. The heat units were calculated for each interval of four minutes, as shown in the table, and their sum taken for the whole interval. The scale reading and number of revolutions of the dynamometer were averaged for the time of the experiment, the work being calculated from the means (Philadelphia time).

CONTINUOUS CALIBRATION.—TATHAM DYNAMOMETER, June 27, 1885.

TIME.	Mean temperature exit.	Mean temperature entrance.	Increase.	Weight H_2O.	Heat units.
11.02					
.06	39.528	23.82	15.708	287.25	4512.123
.10	39.5975	23.8225	15.775	267.00	4211.925
.14	39.65	23.8125	15.8375	261.25	4137.546875
.18.30	39.7125	23.815	15.8975	293.75	4669.890625
.22	39.7025	23.82	15.8825	235.00	3732.3875
.26.30	39.67	23.8025	15.8675	310.50	4926.85875
.30	39.645	23.80	15.845	228.75	3624.54375
.34	39.6125	23.80	15.8125	271.25	4289.140625
.38	39.6150	23.805	15.810	274.00	4331.94
.42	39.5875	23.8025	15.785	270.75	4273.78875
.46	39.5875	23.8275	15.76	274.00	4318.24
.50	39.5375	23.845	15.6925	276.00	4331.13
.54	39.52	23.8525	15.6675	275.00	4308.5625
.58	39.485	23.84	15.645	276.00	4318.02
12.02	39.4450	23.84	15.605	277.75	4334.28875
.06	39.3425	23.85	15.4925	289.00	4477.3325
.10	39.255	23.86	15.395	286.25	4406.81875
.14	39.1425	23.8825	15.26	287.00	4379.62
.18	39.0775	23.8925	15.185	284.75	4323.92875
.22	39.0125	23.90	15.1125	284.00	4291.95
.26	38.98	23.91	15.07	289.25	4358.9975
.30	38.895	23.91	14.985	287.50	4308.1875
.34	38.865	23.91	14.955	290.50	4344.4275
.38	38.78	23.905	14.875	293.50	4365.8125
.42	38.8175	23.915	14.9025	275.50	4105.63875
.46	38.93	23.925	15.005	272.25	4085.11125
.50	39.04	23.925	15.115	270.50	4088.6075
.54	39.175	23.94	15.235	265.50	4044.8925
.58	39.3475	23.925	15.4225	263.50	4063.82875
1.02	39.405	23.9125	15.4925	271.00	4198.4675
.06	39.45	23.9025	15.5475	273.25	4248.354375
1.10	39.4825	23.90	15.5825	272.50	4246.23125
.14	39.485	23.92	15.565	273.00	4249.245
.18	39.4925	23.92	15.5725	268.00	4173.43
.22	39.525	23.905	15.62	267.50	4178.35
.26	39.51	23.90	15.61	274.75	4288.8475
.30	39.52	23.895	15.625	268.00	4187.5
Total number heat units					157735.96550

When the experiment was finished, the two cocks on the calorimeter were closed, and the engine stopped. The temperature of the water was then found to be 39°. The time occupied in stopping was about four minutes, equivalent to two minutes on full load. From the data of the previous experiment, the rise of temperature would be about .85° C. per minute, and therefore the average temperature of the calorimeter during the second experiment was about 37.3°.

From the above table and the dynamometer record, we get the following data:

Mean reading scale beam,	655.9195
Mean friction reading,	13.72
Corrected reading,	642.1995
No. revolutions,	106,180
Foot pounds absorbed,	225585395.
Heat units passing through cal. (uncorrected),	157735.96
Heat units radiated from calorimeter,	+ 4045.89
Correction to reduce ther. to abs. temp.,	— 169.63
Stem correction,	+ 647.12
Total heat units,	162169.34
Mechanical equivalent for 1° C.,	1391.05 foot pounds.
Mechanical equivalent for 1° F.,	772.81 foot pounds.

In this method the uncertainty due to the specific heat of the iron, and its temperature is avoided. The greatest possibilities of error are in the mean temperature of the calorimeter and the stem correction. It is probable that too great a value of the latter has been taken; for the thermometers were in the water for several hours and a considerable portion of the stem must have been heated by conduction.

The coefficient of radiation was taken from the first experiment.

The results of the experiments are:

First method mech. equiv. = 768.3 + an indeterminate cor.
Second method mech. equiv. = 772.81.

It would seem then that within the limit of error of these experiments, the dynamometer is correct, and, considering the probable accuracy of the last method, there seems little doubt that the work calculated from the dynamometer readings is as accurate as the adjustments of the machine and the readings themselves.

TESTS.

For the full load tests, the machines were run at least 10 hours before any measurements were made. They were then tested at intervals of from one to two hours.

For the partial loads, the dynamos were run on quarter load for two or three hours, then tested, then run on half load for a couple of hours, and tested, etc.

The method of making a test was as follows: A time to begin was set, and the observers got ready to start at the signal from the test house. After the signal, double readings of the potential and current galvanometers were simultaneously made each minute, and the scale beam and number of revolutions of the dynamometer observed. The field galvanometer was reversed, and read as often as possible, usually four or five double readings.

At the end of 10 minutes, a signal to stop was made; the dynamo was stopped, the field circuit broken, the storage battery put on, and the armature resistance measured. The brushes were then lifted, and the field circuit made and its resistance measured. Finally, the constants of the current and potential galvanometers were checked on the german silver strips.

When the tests for the day were finished, the friction of the armature and of the dynamometer were obtained, and

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the latter subtracted from the power applied for each test.

Communication from the test house to the dynamo shed was by an electric bell, and through a speaking tube.

The following notation will be used in the formulæ:

- e differ. of potential between term. of dynamo;
- E total electromotive force generated in armature;
- i current in external circuit;
- i_s current in field;
- R resistance of external circuit;
- r_a resistance of armature coils;
- r_s resistance of field with box for adjustment;
- S resistance of field alone;
- W energy applied in horse-power;
- W_t total electrical energy in horse-power;
- W_e energy in external circuit in horse-power;
- W_a energy in armature in horse-power;
- W_s energy in field in horse-power;
- Ef_t total efficiency of electrical conversion;
- Ef_c useful commercial efficiency;
- η $= Ef_c / Ef_t$;
- ρ_a percentage of power used in armature;
- ρ_s percentage of power used in field;
- n number of revolutions per minute;
- *Fric.* friction of armature;
- t_a temperature of the air in degrees centigrade;
- t_p temperature of pole-piece in degrees centigrade;

Of these, e, i, i_s, r_a, S, W, n, t_a and t_p were observed directly.

E was calculated from $E = e + (i + i_s)\, r_a$;

R was obtained from $R = e / i$;

r_s was from $r_s = e / i_s$; it was also checked by observation after each test.

The other formulæ used were

$$W_t = \frac{(i + i_s)\, e + (i + i_s)^2 r_a}{745.3}$$

$$W_e = \frac{i\, e}{745.3}$$

$$W_a = \frac{(i + i_s)^2 r_a}{745.3}$$

$$W_s = \frac{i_s\, e}{745.3}$$

$$Ef_t = \frac{W_t}{W}$$

$$Ef_c = \frac{W_e}{W}$$

$$\eta = \frac{Ef_c}{Ef_t}$$

$$\rho_a = \frac{W_a}{W}$$

$$\rho_s = \frac{W_s}{W}$$

EDISON NO. 5 DYNAMO.

Diameter of armature,	$7\frac{1}{16}''$ inner; $7\frac{7}{8}''$ outer.
Weight of machine,	2475 pounds.
Number of commutator bars,	50
Turns of wire in a coil,	2
Length of useful wire in a coil,	52″
Brushes adjusted or not?	yes.
Diameter of bearing,	$1\frac{5}{16}''$
Length of bearing,	$5\frac{5}{8}''$
Revolutions per minute,	1400
Volts for best work,	125
Ampères for best work,	100

Table I gives the result of the measurements:

This was the first machine tested and the measurements were intended as much to show any weak points in the method as to serve as a test of the dynamo. If no trouble occurred, the work was to be accepted, otherwise it would have been repeated after the causes of error had been removed.

On looking at the table, it will be seen that the efficiencies for the two tests differ by about one per cent. The agreement of the measurements of the current and potentials as shown in the values of the resistances, calculated

TABLE I.—(*Edison No. 5 Dynamo.*)

DATE.	May 29th.		
Time,	12.40	1.40	3.00
Load,	Full.	Full.	Insulation of armature gave way.
E. M. F. at terminals	125.2	121.59	
Total E. M. F.	131.5	128.00	
Current in ext. circuit	100.92	98.06	
Current in field	2.385	2.296	
External resistance	1.241	1.240	
Armature resistance	.0618	.0638	
Field, with box	52.59	53.08	
Field, alone	......	......	
Power applied	18.89	18.05	
Total electric energy	18.23	17.24	
Ext. electric energy	16.95	16.00	
Energy in armature	.878	.863	
Energy in field	.401	.374	
Total efficiency	96.53	95.49	
Commercial efficiency	89.76	88.63	
Economic coefficient	92.99	92.82	
% power in armature	4.65	4.78	
% power in field	2.12	2.08	
No. revolutions	1400.8	1389.7	
Friction of armature	......	......	
Temperature of air	26.4° C.	27.° C.	
Temperature of pole piece	44.° C.	45.4° C.	

from them, is very good. Whether the difference is due to the power measurements, or to different conditions of lubrication, velocity, etc., is impossible to say.

After the second test, the insulation of the armature gave way; making it impossible to repeat the full load measurements, or to test on the partial loads.

EDISON NO. 10 DYNAMO.

Diameter of armature,	$9\frac{11}{16}''$ inside; $10\frac{5}{8}''$ outside.
Weight of machine,	4710 pounds.
Number of commutator bars,	64
Turns of wire in a coil,	1
Length of useful wire in a coil,	33″
Must brushes be adjusted?	yes.
Diameter of bearing,	$2\frac{3}{8}''$
Length of bearing,	$9\frac{5}{8}''$
Number of turns per minute,	1200
Volts for best work,	125
Ampères for best work,	200

Table II gives the results of the measurements:

There is little to say of the full load measurements of this machine. The extreme difference is about one-half per cent.; the greatest difference from the mean one-fourth per cent.

The dynamo was measured twice on the partial loads. The first set was on the same day as the full load tests, the machine being run on open circuit for a couple of hours after the last full load measurement, then tested for quarter load, then run on half load for a while and tested, etc. The second set, made some days later, showed that the machine had not been sufficiently cooled for the first set of measurements. The total efficiencies, calculated from the two sets of measurements, differ for the quarter load about one and one-half per cent; for the half load, three-quarter per cent., and for the three-quarter load, one-seventh per cent.

In comparing these total efficiencies, if the difference of armature friction (.152 h. p.) be applied to the first set, we get

	¼ load.	½ load.	¾ load.
First set,	83.10	90.51	92.83
Second set,	83.32	90.55	92.44

But as the measurement of friction was made after the three-quarter load in each case, the values for this load should agree better than for the others. Part of the difference of .39 per cent. is undoubtedly due to the fact that in the last set of measurements the unsteadiness of the potential galvanometer while measuring the armature resistance, due to changes in the contact resistance of the brushes, was

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so great that the brushes were held against the commutator, thus giving too small a value of r_a, and therefore of Ef_t. On the whole, the agreement of the two sets is very satisfactory.

TABLE II.—(*Edison No. 10 Dynamo.*)

DATE.	June 1st.				June 1st.			June 4th.		
Time,	12.33	2.00	3.15	4.15	6.56	7.45	8.30	11.15	2.35	4.00
Load,	Full.	Full.	Full.	Full.	¼	½	¾	¼	½	¾
E. M. F. at terminals	125.08	122.67	121.58	122.87	125.41	126.09	122.89	127.81	128.83	125.6
Total E. M. F	129.35	127.18	126.05	127.27	126.81	128.74	126.85	128.73	130.67	128.33
Current in ext. circuit	201.48	196.51	194.56	196.48	52.07	107.05	150.60	51.81	103.79	149.92
Current in field	4.021	3.900	3.84	3.93	3.46	3.69	3.74	3.47	3.81	3.81
External resistance*	$.6208_e$	$.6243_e$	$.6249_e$	$.6254_e$	2.408_d	1.177	$.8160_d$	2.467_d	1.[illegible]13$_d$	.8378
Armature resistance	.0208	.0225	.0231	.0220	.0253	.0239	.0256	.0167	.0171	.0178
Field, with box	31.10	31.46	31.63	31.27	36.24	34.14	32.83	36.82	33.83	33.01
Field, alone	......	......	......	......	......	......	......	......	......	......
Power applied	37.69	35.98	35.53	36.19	11.556	21.30	28.46	11.459	20.83	28.64
Total electric energy	35.67	34.20	33.58	34.22	9.449	19.13	26.27	9.548	18.86	26.47
Ext. electric energy	33.81	32.34	31.74	32.66	8.762	18.11	24.83	8.884	17.94	25.27
Energy in armature	1.178	1.212	1.218	1.182	.105	.393	.820	.0686	.265	.564
Energy in field	.675	.642	.627	.648	.582	.625	.617	.595	.658	.641
Total efficiency	94.61	95.04	94.52	94.56	81.77	89.80	92.30	83.32	90.55	92.44
Commercial efficiency	89.70	89.89	89.34	89.52	75.82	85.02	87.25	77.53	86.12	88.23
Economic coefficient	94.80	94.58	94.51	94.65	92.73	94.68	94.53	93.05	95.10	95.45
% power in armature	3.12	3.36	3.43	3.26	.906	1.85	2.88	.598	1.28	1.97
% power in field	1 80	1.79	1.76	1.78	5.04	2.93	2.16	5.20	3.16	2.24
No. revolutions	1208.6	1197.6	1193.3	1199.3	1207.6	1207.7	1202.6	1211.7	1211.1	1209.3
Friction of armature	.437	.437	.437	.437	.437	.437	.437	.285	.285	.285
Temperature of air	30.5° C.	30.5° C.	30.5° C.	28.° C.	26.5° C.	27.5° C.	27.0° C.	25.5° C.	28.5° C.	31.0° C.
Temperature of pole-piece	50.5° C.	50.5° C.	51.5° C.	56.6° C.	35.5° C.	44.5° C.	44.0° C.	38.0° C.	45.6° C.	46.7° C.

*The suffix e refers to lamps and d to "dead" resistance.

WESTON NO. 7 M. DYNAMO.

Diameter of armature,	9⅝″
Weight of machine,	3300
Number of commutator bars,	64
Total number of turns in coils,	128
Turns per commutator segment,	2
Average length of a turn,	6 feet, 8″
Must brushes be adjusted?	slightly.
Diameter of bearing, pulley end,	2″
Diameter of bearing, commutator end,	1½″
Length of bearing, pulley end,	7½″
Length of bearing, commutator end,	6½″
Number of turns per minute,	1050
Volts for best work,	160
Ampères for best work,	125

Table III gives the results of the measurements:

TABLE III.—(*Weston No. 7 M. Dynamo.*)

DATE.	June 8th.				June 12th.				
Time,	11.15	12.26	2.27	3.45	12.00	2.00	3.45	4.30	6.00
Load,	Full.	Full.	Full.	Full.	¼	½	¾	Full.*	½
E. M. F. at terminals	156.07	154.84	151.42	151.22	163.66	163.41	163.93	166.48	167.60
Total E. M. F	165.58	163.99	160.79	160.31	166.07	168.29	172.65	176.30	172.77
Current in ext. circuit	125.78	124.86	123.13	123.57	33.26	66.27	99.25	133.82	67.68
Current in field	2.378	2.340	2.341	2.332	1.738	1.872	2.163	2.439	1.959
External resistance	1.241_d	1.240	1.230_e	1.224_e	4.921_d	2.466_d	1.652_d	1.244_d	2.476_d
Armature resistance	.0742	.0720	.0747	.0722	.0689	.0716	.0683	.0720	.0742
Field, with box	65.62	66.18	64.70	64.86	94.16	87.31	75.78	68.25	85.54
Field, alone	......	......	......	......	......	......	......	......	......
Power applied	29.29	29.01	28.07	28.17	8.658	16.223	24.123	33.257	17.08
Total electric energy	28.47	27.98	27.07	27.08	7.798	15.387	23.25	32.23	16.144
Ext. Electric energy	26.34	25.94	25.02	25.07	7.304	14.53	21.83	29.89	15.22
Energy in armature	1.635	1.562	1.578	1.536	.1131	.446	.943	1.796	.483
Energy in field	.498	.486	.476	.473	.382	.410	.476	.545	.441
Total efficiency	97.21	96.48	96.45	96.12	90.08	94.84	96.38	96.92	94.52
Commercial efficiency	89.92	89.42	89.14	89.00	84.37	89.57	90.49	89.87	89.12
Economic coefficient	92.51	92.68	92.41	92.58	93.65	94.41	93.90	92.73	94.28
% power in armature	5.59	5.39	5.63	5.45	1.31	2.75	3.91	5.40	2.82
% power in field	1.70	1.68	1.69	1.68	4.41	2.53	1.98	1.63	2.58
No. revolutions	1043.5	1039.0	1045.6	1051.7	1041.4	1038.8	1024.1	1058.8	1051.3
Friction of armature	.3115	.3115	.3115	.3115	.1956	.1956	.1956	.1956	.1956
Temperature of air	30.° C.	30.5° C.	30.° C.	30.° C.	29.5° C.	31.° C.	30.5° C.	29.° C.	28.° C.
Temperature of pole-piece	42.° C.	42.2° C.	42.8° C.	47.8° C.	33.3° C.	35.° C.	36.5° C.	36.° C.	35.5° C.

*Unofficial.

As stated under "potential measurements," there was a sharp change in the value of the constant of the potential galvanometer between the second and third tests. The following are the calibrations made:

TIME.	Value of K_{80}.	METHOD.
A. M.	at 25 degrees.	
10.00	1.306	Voltameter with standard resistance.
11.35	1.307	Current galvanometer with german silver strips.
P. M.		
12.50	1 308	Current galvanometer with german-silver strips.
2.50	1.287	Current galvanometer with german-silver strips.
3.05	1.286	Voltameter with standard resistance.
4.15	1.286	Voltameter with standard resistance.

For the first two tests, the value 1.306 was used; for the last two, 1.286.

The tables show a gradual decrease in the efficiencies, the difference between the first and last values being about one per cent.

The cause seems to be the different amounts of lead given the brushes. If we compare the first with the third test, it will be seen that, with about the same current in the field and a greater number of revolutions of the armature, the E. M. F. of the latter test is about five volts less than that of the former. In the last test, with the speed still further increased and with the field current about constant, the E. M. F. is slightly less than in the third measurement.

The partial load tests were made after the constant had become steady. After the three-quarter load test, a

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measurement was made on full load. As it was not made under the provisions of the code, it is marked "unofficial" in the table. The half load test was repeated to check the former measurement. The difference of .3 per cent. in the total efficiencies is probably accounted for by the slight increase of armature friction caused by running on the three-quarter load. The greatest value of the commercial efficiency is on three-quarter load, the slightly less value of the total efficiency, as compared with the full load, being more than counter-balanced by the smaller loss in the armature and field.

WESTON NO. 6 M. DYNAMO.

Diameter of armature,	8 1/16″
Weight of Machine,	2000
Number of commutator bars,	72
Total number of turns,	144
Turns per commutator segment,	2
Average length of a turn,	6 feet 5″
Must brushes be adjusted?	slightly.
Diameter of bearing, pulley end,	1⅝″
Diameter of bearing, commutator end,	1⅜″
Length of bearing, pulley end,	6¾″
Length of bearing, commutator end,	5″
Number of turns per minute,	1150
Volts for best work,	120
Ampères for best work,	80

Table IV. gives the results of the measurements:

TABLE IV.—(*Weston No. 6 M. Dynamo.*)

Date.	June 13th.				June 14th.			
Time,	11.52	1.50	2.25	3.55	12.15	2.20	4.00	4.39
Load,	Full.	Full.	Full.	Full.	¼	½	¾	Full.*
E. M. F. at terminals	117.4	115.4	118.89	119.86	119.70	122.41	119.19	124.41
Total E. M. F.	124.59	122.37	126.26	127.17	121.70	126.28	125.12	131.76
Current in ext. circuit	71.85	70.62	72.45	71.56	20.535	39.878	60.705	75.65
Current in field	1.277	1.254	1.280	1.286	1.236	1.214	1.246	1.318
External resistance	1.634d	1.634d	1.641d	1.675e	5.827e	3.070e	1.963d	1.645d
Armature resistance	.0983	.0969	.0999	.1003	.0921	.0940	.0957	.0956
Field with box	91.93	92.00	92.91	93.20	96.79	100.9	95.69	94.42
Field alone	......	......	......	......	......	......	......	......
Power applied	12.89	12.48	13.15	13.17	3.979	7.341	10.774	14.390
Total electric energy	12.23	11.80	12.49	12.429	3.554	6.962	10.40	13.606
Ext. electric energy	11.32	10.93	11.56	11.508	3.297	6.55	9.708	12.727
Energy in armature	.705	.672	.729	.714	.0585	.213	.493	.759
Energy in field	.201	.194	.204	.207	.1985	.1993	.1992	.2199
Total efficiency	94.82	94.53	94.98	94.37	89.33	94.84	96.53	94.55
Commercial efficiency	87.79	87.59	87.88	87.38	82.87	89.23	90.10	87.75
Economic coefficient	92.58	92.66	92.53	92.59	92.77	94.08	93.34	92.80
% power in armature	5.48	5.38	5.56	5.43	1.47	2.90	4.58	5.28
% power in field	1.56	1.57	1.56	1.57	4.99	2.71	1.85	1.53
No. revolutions	1099.6	1101.9	1117.8	1114.9	1110.7	1109.5	1113.7	1154.2
Friction of armature	.298	.298	.298	.298	.1672	.1672	.1672	.1672
Temperature of air	30.4° C.	31.° C.	30.5° C.	30.5° C.	34.° C.	33.5° C.	......	......
Temperature of pole-piece	37.7° C.	41.2° C.	41.6° C.	41.5° C.	36.7° C.	39.5° C.	......	......

*Unofficial.

The full load measurements probably agree as closely as the conditions of the tests. There was a good deal of sparking at the brushes, and the machine seemed over-loaded.

For the partial loads, the total efficiency increased up to the three-quarter load, and there was little sparking at the commutator. On the unofficial full load test, the sparking was quite violent, and the efficiency fell about two per cent. from the three-quarter load. Comparing the unofficial full load with the tests of the day before, and applying the difference of armature friction to the former, it will be seen that the total efficiency for the unofficial test is less, the load being greater and the efficiency at this load decreasing rapidly as the load increases.

EDISON NO. 4 DYNAMO.

Diameter of armature, 6¼″ inside,	7 1/16″ outside.
Weight of machine,	1470
Number of commutator bars,	50
Turns in one coil,	2
Length of useful wire in a coil,	48″
Must brushes be adjusted?	yes.
Diameter of bearing,	1½″
Length of bearing,	6¼″
Turns per minute,	1600
Volts for best work,	125
Ampères for best work,	80

Table V gives the results of the measurements:

TABLE V.—(*Edison No. 4 Dynamo.*)

DATE.	June 16th.				June 17th.			
Time,	2.16	3.30	4.25	5.20	11.00	12.15	2.15	2.40
Load,	Full.	Full.	Full.	Full.	¼	½	¾	Full.*
E. M. F. at terminals	120.05	124.95	125.20	126.75	128.66	128.77	128.39	131.17
Total E. M. F.	124.64	129.61	129.97	131.91	130.00	131.09	132.22	137.08
Current in ext. circuit	72.919	75.93	76.12	82.10	22.36	39.55	63.58	90.68
Current in field	1.915	2.244	2.211	2.321	1.940	2.082	2.222	2.647
External resistance	1.646d	1.646d	1.647d	1.543e	5.755e	3.256d	2.019e	1.446e
Armature resistance	.0614	.0596	.0610	.0611	.0550	.0556	.0582	.0634
Field, with box	62.68	55.68	56.63	54.58	66.33	61.85	57.78	49.55
Field, alone	44.17	44.46	44.69	44.59	40.42	41.21	42.29	.....
Power applied	13.284	14.383	14.442	15.786	5.050	8.168	12.517	18.053
Total electric energy	12.51	13.60	13.64	14.93	4.237	7.322	11.67	17.17
Ext. electric energy	11.746	12.73	12.77	13.95	3.859	6.833	10.95	15.96
Energy in armature	.461	.488	.501	.584	.0436	.129	.338	.741
Energy in field	.309	.376	.371	.394	.335	.360	.382	.466
Total efficiency	94.21	94.53	94.47	94.58	83.89	89.65	93.26	95.09
Commercial efficiency	88.42	88.52	88.43	88.38	76.40	83.65	87.50	88.40
Economic coefficient	93.85	93.64	93.61	93.45	91.07	93.32	93.82	92.97
% of power in armature	3.47	3.40	3.47	3.70	.86	1.59	2.70	4.10
% of power in field	2.32	2.61	2.57	2.49	6.63	4.41	3.06	2.58
No. revolutions	......	......	......	......	......	......	......	......
Friction of armature	.14	.14	.14	.14	.16	.16	.16	.16
Temperature of air	35.5° C.	36.5° C.	36.2° C.	36.° C.	21.° C.	23.° C.	25.° C.	24.8° C.
Temperature of pole-end	45.8° C.	45.5° C.	46.1° C.	45.5° C.	27.2° C.	29.5° C.	33.3° C.	34.6° C.

*Unofficial.

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This machine was not coupled directly to the dynamometer, the high speed required being deemed unsafe. It was run by a belt from a pulley on the transmission shaft of the dynamometer. In allowing for the loss due to the belt, it was assumed that for the full load the friction of the armature was the same as that of the No. 5 dynamo.

The full load tests agree very closely, the total efficiencies increasing slightly with the horse-power. The commercial efficiencies differing very little.

The measurements on the partial loads are perhaps a little low, as it is probable that sufficient allowance was not made for the belt. The temperature was much lower than for the full load tests and the belt was probably stiffer.

EDISON NO. 20 DYNAMO.

Diameter of armature,	$9\frac{11}{16}$ inside, $10\frac{5}{8}$ outside.
Weight of machine,	8331 pounds.
Number of commutator bars,	44
Turns of wire in a coil,	1
Length of useful wire in a coil,	59″
Must brushes be adjusted?	yes.
Diameter of bearing,	$2\frac{5}{8}$″
Length of bearing,	$10\frac{7}{8}$″
Number of turns per minute,	1000
Volts for best work,	125
Ampères for best work,	400

Table VI. gives the results of the measurements :

TABLE VI.—(*Edison No. 20 Dynamo.*)

DATE.	June 18th.			June 19th.			
Time,	1.00	2.25	3.50	9.45	1.30	2.45	4.00
Load,	¼	½	¾	Full.*	Full.*	Full.*	Armature insulation gave way.
E. M. F. at terminals	126.16	122.0	123.99	105.95	125.04	125.4	
Total E. M. F.	127.46	124.10	127.55	110.00	129.60	129.95	
Current in ext. circuit	100.22	192.46	291.16	330.88	387.28	379.00	
Current in field	4.942	4.915	5.124	4.397	5.136	5.124	
External resistance	1.252d	.6338	.4161d	.3202d	.3229d	.3308e	
Armature resistance	.0124	.0106	.0120	.0121	.0116	.0119	
Field, with box	25.53	24.82	24.20	24.10	24.35	24.47	
Field, alone	......	......	......	......	......	......	
Power applied	20.254	35.43	53.11	51.06	70.72	69.39	
Total electric energy	17.985	32.86	50.71	49.48	68.25	66.97	
Ext. electric energy	16.965	31.50	48.44	47.04	64.99	63.76	
Energy in armature	.1838	.556	1.416	1.82	2.40	2.35	
Energy in field	.837	.809	.852	.625	.862	.862	
Total efficiency	88.80	92.77	95.46	96.91	96.51	96.52	
Commercial efficiency	83.76	88.93	91.19	92.11	91.90	91.89	
Economic coefficient	94.33	95.86	95.53	95.06	95.22	95.21	
% power in armature	.91	1.57	2.66	3.57	3.39	3.38	
% power in field	4.18	2.27	1.61	1.23	1.22	1.25	
No. revolutions	1008.9	1023.9	1008.8	1022.3	1092.1	1090.2	
Friction of armature	......	......	......	.393	.393	.393	
Temperature of air	28.5° C.	28.5° C.	28.5° C.	31.5° C.	33.° C.	33.5° C.	
Temperature of pole-piece	35.0° C.	37.8° C.	38.3° C.	44.5° C.	45.° C.	47.8° C.	

*Unofficial.

The full load tests are marked unofficial, because the preliminary run of ten hours was not on full load. The machine was started at the usual time, midnight, with about the right load, but in a few hours the power fell to about 50 h. p., and remained about the same until noon of June 19th, when by increasing the number of revolutions, the proper road was nearly attained. The tests were to have been repeated the next day, but unfortunately the insulation of the armature gave way, making this impossible.

The tests seem to agree quite well. It is hard to compare the first full load measurement with the others as the conditions were different. The two full load measurements made under about the same conditions agree almost exactly.

WESTON NO. 6 W. I. DYNAMO.

Diameter of armature,	$8\frac{1}{4}$″
Weight of machine,	2100 pounds
Number of commutator bars,	56
Total number of turns in armature coils,	112
Turns per commutator segment,	2
Average length,	6 feet, $3\frac{1}{2}$″
Must brushes be adjusted?	slightly
Diameter of bearing, pulley end,	$1\frac{5}{8}$″
Diameter of bearing, commutator end.	$1\frac{3}{8}$″
Length of bearing, pulley end,	$6\frac{3}{4}$″
Length of bearing, commutator end,	5″
Turns per minute,	1200
Volts for best work,	130
Ampères for best work,	100

Table VII gives the results of the measurements :

TABLE VII.—(*Weston No. 6 W. I. Dynamo, 130 Volts.*)

DATE.	June 22d.		June 23d.				
Time,	......	2.00	12.40	2.20	3.35	4.35	5.35
Load,	¼	½	Full.*	Full.	Full.	Full.	¾
E. M. F. at terminals	125.06	124.29	128.45	129.00	124.8	131.8	133.7
Total E. M. F.	126.17	126.34	133.12	133.87	129.89	136.22	137.19
Current in ext. circuit	25.51	46.19	108.94	109.29	114.2	98.33	81.99
Current in field	2.051	2.144	2.239	2.213	2.171	2.272	2.242
External resistance	4.901d	2.691d	1.180d	1.180d	1.093e	1.340e	1.630e
Armature resistance	.0404	.0424	.0420	.0437	.0438	.0439	.0441
Field, with box	60.96	57.96	57.37	58.28	57.51	58.01	59.62
Field, alone	......	......	......	......	......	......	......
Power applied	5.092	8.820	20.98	20.71	21.01	19.28	16.48
Total electric energy	4.666	8.193	19.86	20.03	20.29	18.39	15.50
Ext. electric energy	4.281	7.703	18.78	18.92	19.13	17.39	14.70
Energy in armature	.0412	.1329	.697	.729	.795	.596	.394
Energy in field	.344	.358	.386	.383	.364	.402	.402
Total efficiency	91.64	92.89	94.68	96.69	96.58	95.39	94.06
Commercial efficiency	84.07	87.32	89.51	91.32	91.02	90.21	89.22
Economic coefficient	91.74	94.01	94.54	94.45	94.29	94.57	94.86
% power in armature	.81	1.51	3.32	3.52	3.78	3.07	2.39
% power in field	6.76	4.05	1.84	1.85	1.73	2.09	2.44
No. revolutions	1167.2	1168.3	1258.5	1267.6	1250 6	1257.6	1252.3
Friction of armature	......	......	......	.13	.13	.13	.13
Temperature of air	31.° C.	31.° C.	27.5° C.	27.5° C.	25.° C.	25.7° C.	......
Temperature of pole-piece	35.° C.	37.° C.	35.5° C.	35.5° C.	36.7° C.	36.7° C.	......

*Rejected.

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The values of the total efficiency for the different measurements of this machine differ widely. The first test gives a much smaller value than the rest, and is rejected, because, whether the difference is caused by errors in the measurements, or in the adjustment of the machine, the test evidently does not represent the normal efficiency of the dynamo.

Table VIII. gives a summary of the tests:

TABLE VIII.—(*Table of Efficiencies.*)

	Volts.	Ampères.	Weight.	TOTAL EFFICENCIES.				COMMERCIAL EFFICIENCIES.			
				Full Load.‡	¾ Load.	½ Load.	¼ Load	Full Load.‡	¾ Load.	½ Load.	¼ Load.
			lbs.								
Edison, No. 4....	125	80	1,470	94.45	93.26	89.65	83.89	88.44	87.40	83.65	76.40
Edison, No. 5,*..	125	100	2,475	96.01	.....	.....	.....	89.19	.....	.....	.....
Edison, No. 10...	125	200	4,710	94.68	92·44	90.55	83.32	89.61	88.28	86.12	77.53
Edison, No. 20.*.	125	400	8,331	96.65†	95·46	92.77	88.80	91.96†	91.19	88.93	83.76
Weston 6 M.....	120	80	2,000	94.67	96·53	94 84	89.33	87.66	90.10	89.23	82.87
Weston 7 M....	160	125	3,300	96.56	96·38	94.84	90.08	89.37	90.49	89.57	84.37
Weston 6 W. I...	130	100	2,100	96.20	94.06	92.89	91.64	90.85	89.22	87.32	84.07

* Armature insulation gave way. ‡ Average of full load measurements.
† Unofficial.

In the table, the full load efficiencies of the Edison No. 20 dynamo are marked "unofficial," because the preliminary run was not in conformity with the code, not because there is any reason to mistrust the results.

Of the 54 measurements made, four were for obvious reasons deemed unworthy of calculation. These were two tests of the Edison No. 5 dynamo, and a couple of partial load tests of the Weston No. 7 M. machine, made while the constant of the potential galvanometer was unsteady. Of the remaining 50 tests, but one is rejected—a full load measurement of the Weston 6 W. I. dynamo.

Considering the care taken in standardizing all of the instruments used in the measurements, and the very close agreement of tests made on the same dynamo, it seems probable that the results given in the above table represent very nearly the efficiencies of the machines under the conditions of the tests.

The dynamos were favored by being coupled directly to the dynamometer, and it will be seen on looking at the tables that the loss by friction was slight.

In the measurements, the ohm was taken at 106 centimetres of mercury, so in order to reduce the values to absolute measure the potentials, and, therefore, the efficiencies, should be reduced by about one-fourth per cent.

LOUIS DUNCAN, *Chairman.*
GEO. L. ANDERSON, *Secretary.*
WM. D. MARKS,
J. B. MURDOCK,
A. B. WYCKOFF.

PROGRESS IN GAS LIGHTING.

THE efforts being made in the interest of gas to counteract the popularity of electric lighting are shown in the following comments by *Light, Heat and Power* upon the tests at the recent Novelties Exhibition at Philadelphia:

Elsewhere we give the results obtained from the tests made of the various gas burners on exhibition at the Novelties. These results point to one very gratifying feature in the history of gas lighting of the present. This is, that the gas fraternity on this side of the Atlantic is waking up to a realization of the only proper methods for checking the advance of the electric lighting systems. It is of no avail to hold up to the consumers' view the many defects of the electric light. The consumers know all these. They know the uncertainty of supply and the unsteadiness of the glare, and all that, and still, to the dismay of some of our old friends, go on increasing their demand for more light. It may be a gratification, theoretically, to theoretical gas men, that in nearly all cases, gas is piped in connection with the introduction of the electric light; but there is small practical comfort to the practical gas man in the knowledge that the gas supply is considered reliable, but not to be used save in cases of emergency.

Nor does it avail that the higher price of the electric light be alone harped upon. The consumers demand more light and are apparently willing to pay for it. The matter of cost, *per se*, is entirely of secondary consequence.

What must be done is evidently a combination of the defensive arguments that shall change the condition of things to the offensive; and this can be accomplished only by furnishing a greater light for the same cost, or an equal light for less cost. It is in this direction that the gas-burner portion of the display made at the Novelties pointed, and we trust that the march will be straight onward. In the results of the authoritative tests, there is much to be proud of, and yet the excellencies shown only point the way to better achievements.

In all the tests, the results have proven satisfactory to both exhibitors and lookers-on. The Wasserman lamp proved equal to the claims made for it; the Albo-Carbon won friends by its easy method of increasing brilliancy; the incandescent burner was successful in introducing and popularizing its special features; the Siemens gave general satisfaction, as usual; while the Lungren surpassed the expectations of its warmest advocates in so completely distancing the record and substantiating the opinion first given in these columns, that it was the lamp of the year. This last success marked a big stride in gas illumination. What the possibilities of incandescent gas lighting may be, are, as yet, largely problematical. Its exposition upon the present basis, is too new to predict the future from the past, but it was not supposed that the high-water mark of illuminating gas candle-power, reached after years of struggles and slow progress, would be beaten so easily and so completely by a new burner, for which no especial claims were made, save that its illuminating powers were good. We regard the success of the Lungren, not in the light of a wonderful achievement, but as the most substantial encouragement the gas fraternity has met, since the introduction of the electric light, in a persistent fighting out of the war of illumination according to the rules of common sense.

It must be borne in mind that the electric light manufacturers base the relative candle-power claims of their lights upon the comparison afforded by the standard 5′ consumption of gas, yielding from 17 to 20 candle-power. With this, and the cost of gas, at from $1.50 to $2.50 per 1,000′, as a major premis, and the four-cornered candle-power of the arc light as a minor premis, they deduce a conclusion happy to themselves. The Lungren lamp, according to figures elsewhere, practically reduces the cost of gas, in this city, from $1.60 to a little less than 43 cents per 1,000′. Upon the same basis, with gas at $1.50 per 1,000′, the practical illuminating cost would be 40 cents; at $1.25, the practical cost would be 33¼ cents per 1,000′; while at the longed-for "dollar mark," the price of actual illumination would be at the rate of 26⅔ cents per 1,000′. It would seem as though McMillin's "Gas Maker of the Future" might, without trouble, reach the low mark set for him.

For the purposes of illumination upon any scale that requires a centred light of 100 candle-power or more, these figures hold practically good. If the gas fraternity fails to see with what a weapon its own progress has armed it, we are much mistaken. Nor is it to be supposed that the limit of improvement has even been approached. There is more gas in the materials used in generation, and there is more candle-power in the gas. Who will cut the next notch?

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ON THE CHANGES IN THE RESISTANCE COLD OF THE CARBON FILAMENTS OF INCANDESCENT LAMPS.

BY ANTHONY C. WHITE, S. B.

THE following observations on incandescent lamps have been selected from experiments made by the writer in the laboratory of the New England Weston Electric Light Company.

Up to the present time, to my knowledge, no account has been taken either in this country or abroad of the changes which take place in the resistance cold of incandescent lamps, due to disintegration of the carbon filament, or to alterations in its molecular structure.

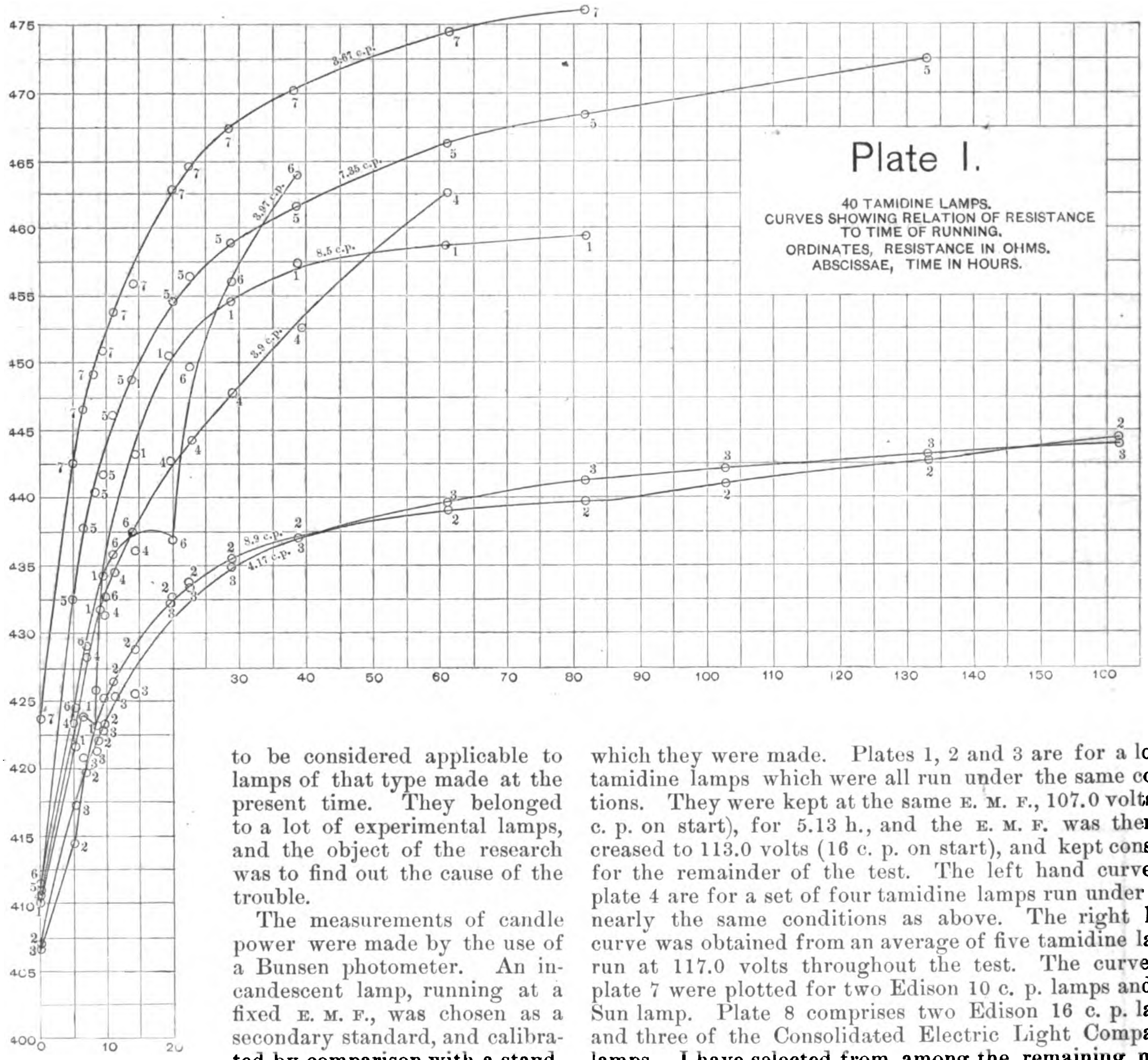
In presenting this paper to the public, the object of the author has not been to draw any unfavorable comparisons between the different types of incandescent lamps, but to show that such changes do take place, and in sufficient amount to materially affect the results of measurements of current strength, E. M. F., efficiency, etc., of incandescent lamps.

The measurements upon the Weston tamidine lamps were introduced simply from their scientific value, and are not to be considered applicable to lamps of that type made at the present time. They belonged to a lot of experimental lamps, and the object of the research was to find out the cause of the trouble.

The measurements of candle power were made by the use of a Bunsen photometer. An incandescent lamp, running at a fixed E. M. F., was chosen as a secondary standard, and calibrated by comparison with a standard candle. A second incandescent lamp was then selected, calibrated by comparison with the standard, and used in all the subsequent measurements of candle power, th standard only being used to detect variations in the second lamp.

The measurements of E. M. F. were obtained by the use of an Ayrton and Perry voltmeter of high resistance, calibrated by Mr. Prescott, of Weston's laboratory.

The measurements of resistance were made on a Wheatstone bridge of very accurate construction, made by Chas. Williams, Jr., of Boston. Its resistance coils had been tested at the physical laboratory of Harvard College, and found to be correct. A temperature correction was applied to reduce the resistance of the carbon filaments to 70° F. The coefficient of reduction used was $\alpha = 0.000366$ (E°). I obtained this value for the Weston tamadine lamp, and have assumed it to be the same for the other varieties of carbon filaments. The value $\alpha = 0.0003704$ was obtained for the Weston Mogul lamp. Curves on plates 5 and 6 are graphical representations of the measurements from which these coefficients were obtained. Plates 1, 2, 3, 4, 7 and 8 represent graphically the changes which take place in the resistance of various incandescent lamps. Measurements of candle power were taken from time to time and their values are placed adjacent to the points at which they were made. Plates 1, 2 and 3 are for a lot of tamidine lamps which were all run under the same conditions. They were kept at the same E. M. F., 107.0 volts (16 c. p. on start), for 5.13 h., and the E. M. F. was then increased to 113.0 volts (16 c. p. on start), and kept constant for the remainder of the test. The left hand curves of plate 4 are for a set of four tamidine lamps run under very nearly the same conditions as above. The right hand curve was obtained from an average of five tamidine lamps run at 117.0 volts throughout the test. The curves on plate 7 were plotted for two Edison 10 c. p. lamps and one Sun lamp. Plate 8 comprises two Edison 16 c. p. lamps and three of the Consolidated Electric Light Company's lamps. I have selected from among the remaining measurements that have not been plotted the following observations:

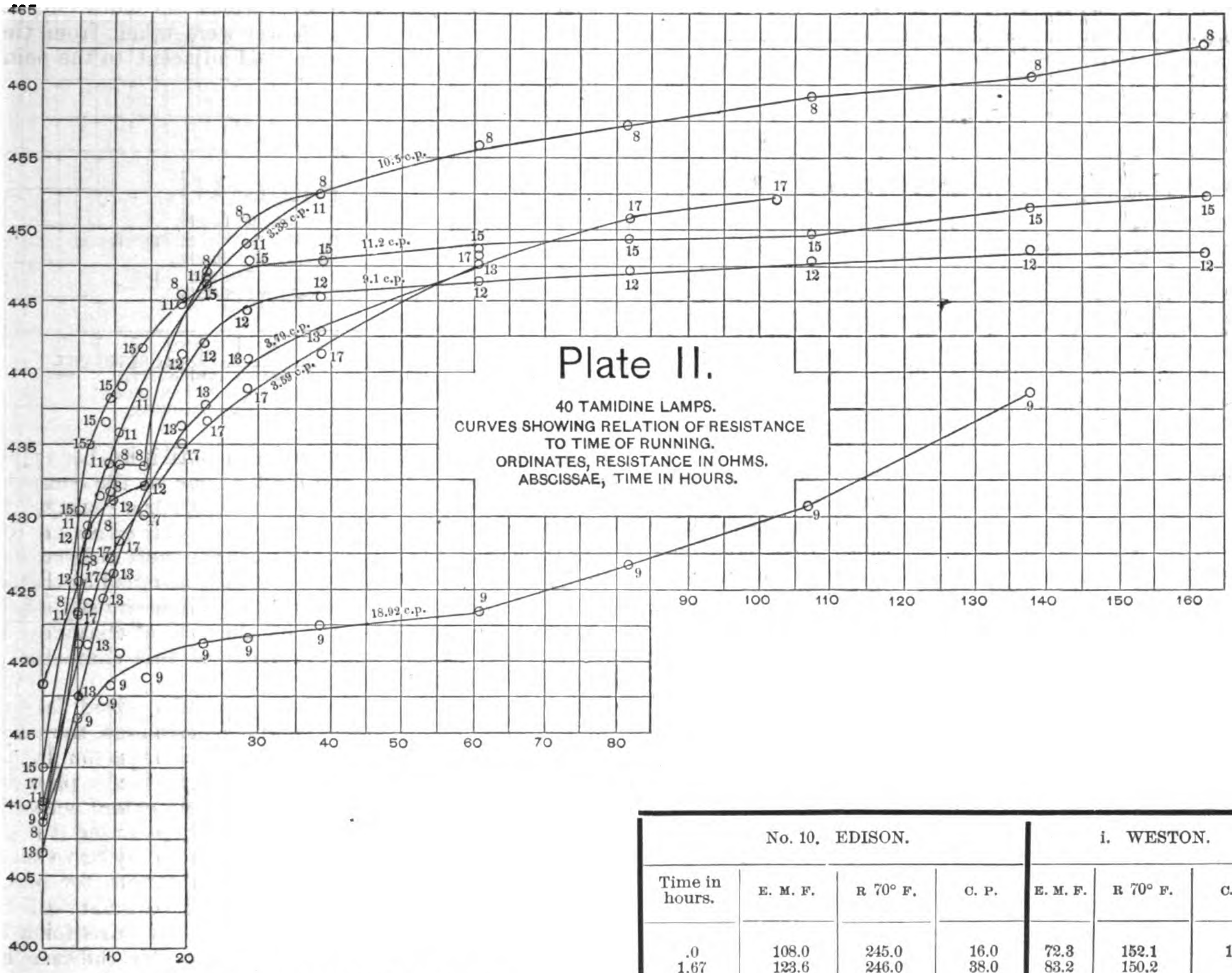


SUN LAMP, NO. 1.

E. M. F.	R 70° F.	Time in hours.	Candle Power.
88.5	177.8	.0	22.0 in a horizontal plane
88.5	180.0	3.75	
88.5	178.1	4.68	
88.5	177.9	12.63	
88.5	182.0	18.21	
88.5	179.0	29.33	
88.5	177.9	48.71	
88.5	177.0	58.33	

NO. 6.

E. M. F.	R 70° F.	Time in hours.	Candle Power.
79.5	168.0	.0	16.0 in a horizontal plane
88.5	167.5	4.77	
79.5	168.0	15.10	
79.5	168.2	21.12	



AVERAGE OF FIVE WESTON PAPER LAMPS (zigzag type).

E. M. F.	R 70° F.	Time in hours.	Candle Power.
72.0	151.9	.0	16.0 in a horizontal plane
72.0	152.3	2.43	
72.0	153.0	11.11	
72.0	152.2	19.11	
72.0	153.0	26.58	
72.0	152.7	39.31	
72.0	153.2	55.32	
72.0	152.2	120.19	
72.0	149.9	159.84	
72.0	150.5	205.22	
72.0	150.1	274.32	14.42 in a horizontal plane
72.0	149.1	458.32	

Edison 16 c. p. lamp and Weston 16 c. p. zigzag paper lamp running at same candle power. (Measured in a horizontal plane.)

No 11. EDISON.				No. 9. WESTON.		
Time in hours.	E. M. F.	R 70° F.	C. P.	E. M. F.	R 70° F.	C. P.
0.00	94.8	221.1	16.0	78.0	154.0	15.26
0.73	102.2	221.8	26.0	80.3	154.9	
6.32	102.2	222.9	26.0	80.3	153.9	
9.32	107.0	223.8	30.0	86.1	153.0	
12.79	109.4	225.2	37.0	88.1	151.1	
17.69	111.9	227.1	40.0	90.0	149.9	
27.32	111.9	230.0	40.0	90.0	150.0	
33.50	114.3	231.6	47.0	91.9	149.7	
45.87	114.3	235.0	47.0	91.9	151.2	
45.87	94.8	235.0	12.5	78.0	151.2	12.56

No. 10. EDISON.				i. WESTON.		
Time in hours.	E. M. F.	R 70° F.	C. P.	E. M. F.	R 70° F.	C. P.
.0	108.0	245.0	16.0	72.3	152.1	16.0
1.67	123.6	246.0	38.0	83.2	150.2	
9.29	123.6	247.9		83.2	146.8	
17.79	123.6	249.5		83.2	146.1	
27.72	123.6	251.2		83.2	145.9	
36.77	123.6	252.3		83.2	145.8	

Blackening of the glass globes, in the case of all the lamps tested, was scarcely perceptible. It was apparently a little more marked in the Edison than in the other types of lamps.

I am fully aware of the incompleteness of this investigation; yet a careful study of the above data will reveal, I think, many interesting facts in relation to incandescent lamps which, to my knowledge, have never before been presented to the public.

1st. It will be noticed that changes take place in the

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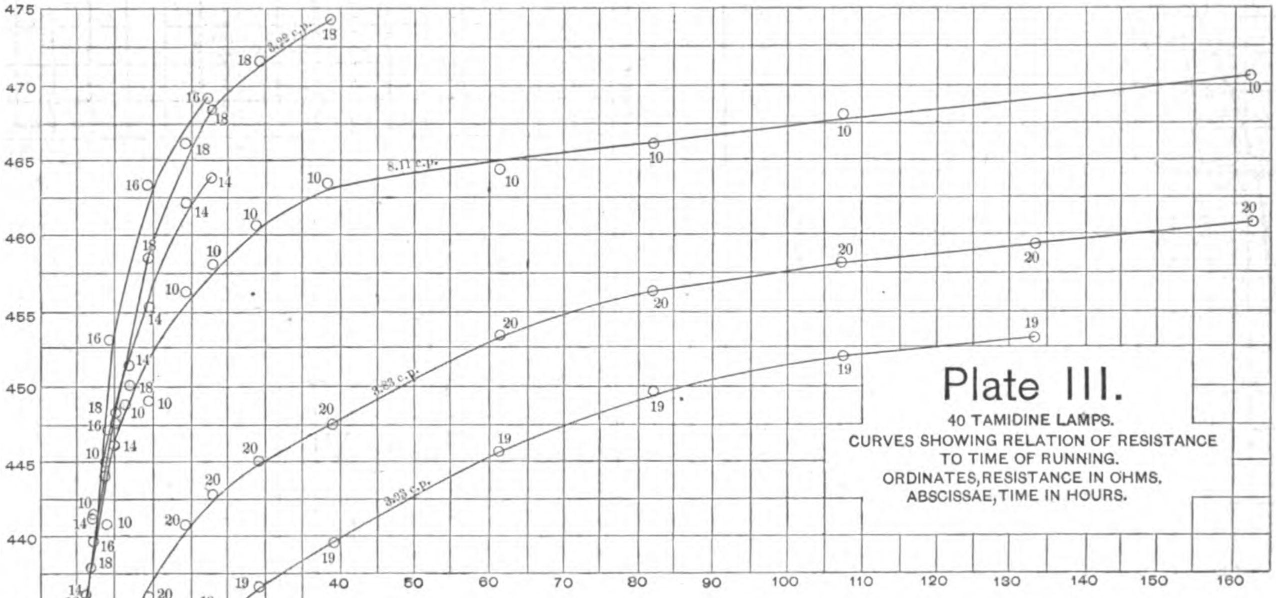
resistance cold of incandescent lamps sufficient to materially affect all measurements made upon the same.

2d. There is a wide difference in the properties of carbon filaments made from different materials and by different processes.

3d. Carbon filaments prepared from the same material and by the same process, in some cases, differ greatly from one another, without apparent reason.

4th. The curves of change of resistance with the time for the Weston tamidine lamps can be represented by an equation of the forms $y = m \times^n$; those for the Edison can be expressed by no simple equation.



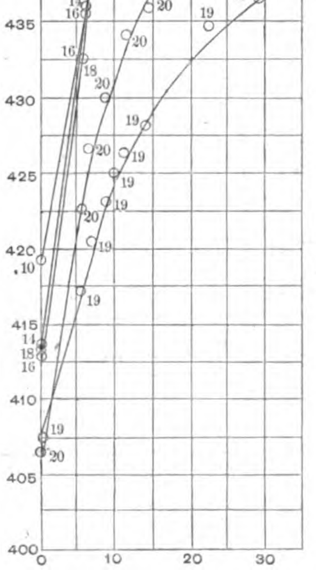


Plate III.
40 TAMIDINE LAMPS.
CURVES SHOWING RELATION OF RESISTANCE TO TIME OF RUNNING.
ORDINATES, RESISTANCE IN OHMS.
ABSCISSAE, TIME IN HOURS.

5th. The curves of those tamidine lamps that broke can be readily distinguished from those that continued to burn throughout the test.

6th. The resistance of the Edison lamps always increased, that of the Weston zigzag paper lamps generally diminished with the time of running. The change for the Consolidated company's lamps was very erratic, but the resistance was usually on the increase. The resistance of the Sun lamps varied according to no fixed law, except in the case of the high resistance lamp No. 2, for which the observations were plotted on plate 7.

7th. The changes in resistance were not generally accompanied by a corresponding change in candle-power.

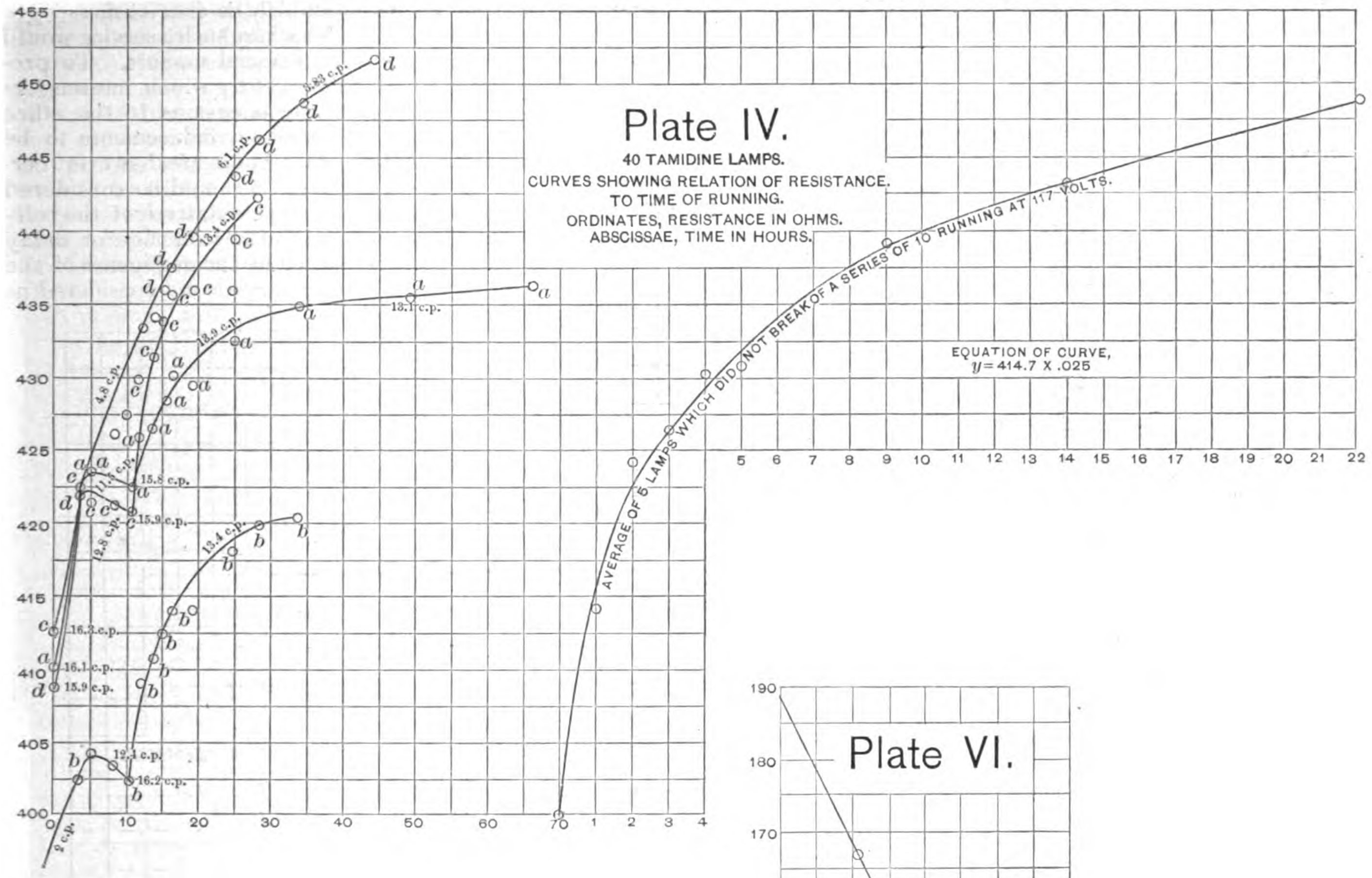
8th. In my opinion the alterations in resistance in the case of the tamidine, Weston zigzag paper, the Sun (except No. 2), and the Consolidated company's lamps were mainly due to modifications of the molecular structure; in the case of the Edison lamps and Sun No. 2, to disintegration of the carbon filaments.

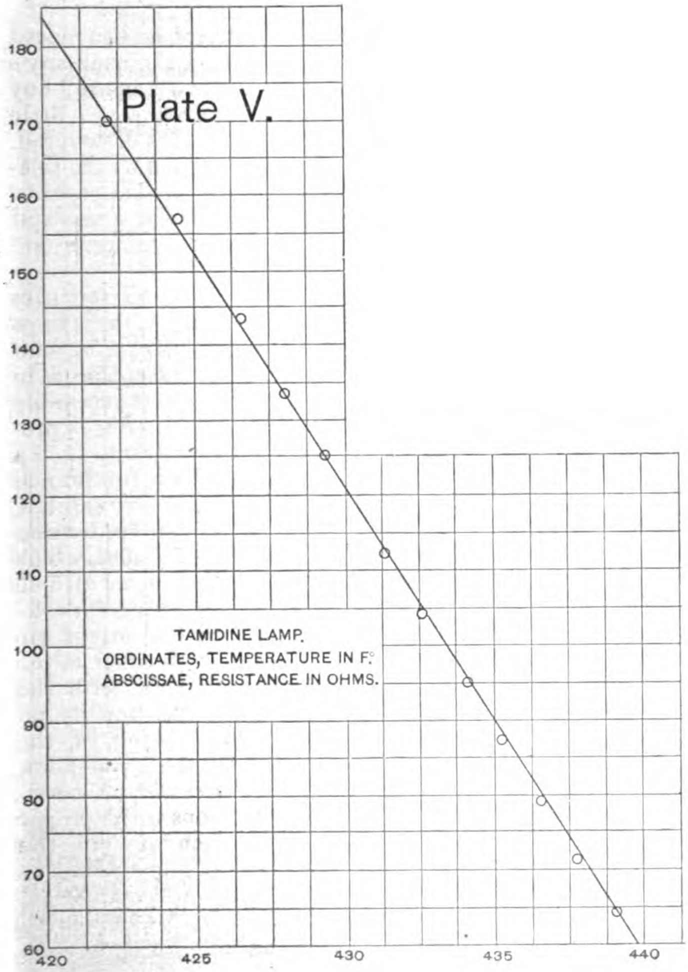
North Dighton, Mass., September, 1885.

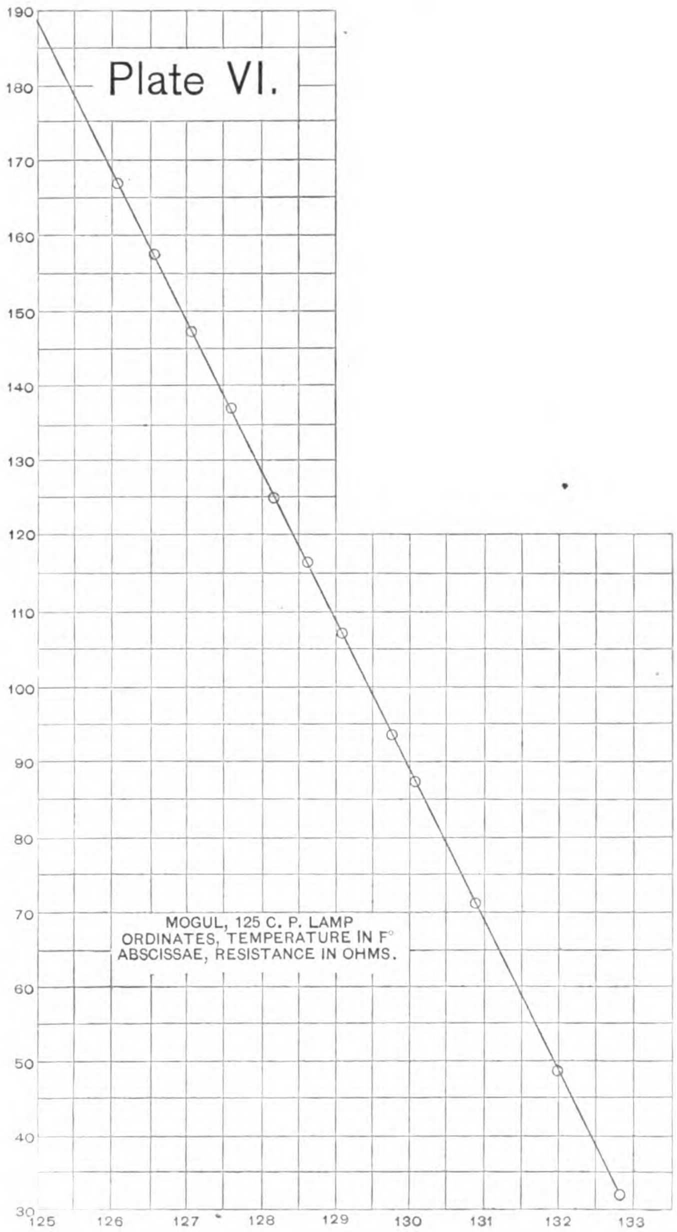
AUTOMATIC BRANCH TELEGRAPH OFFICES.

The eagerness with which rival telegraph companies adopt every promising expedient in order to secure business, has led to the introduction of the district messenger system in many towns and cities where such a service would not otherwise receive sufficient financial support. To provide good customers with call-boxes by which messengers may be summoned to carry their telegrams to the office is now considered one of the necessary inducements to be offered for obtaining patronage. There are, however, certain drawbacks to this feature which should be considered by the customer as well as the representatives of the telegraph company. No claim for either damage or delay can be entertained which is caused by the negligence of the messenger. In other words, a message is not considered as being officially filed for transmission until it has been placed in the hands of a receiving clerk at one of the company's offices. It is quite possible, therefore, for a "smart" boy to destroy a message, pocket the cash, and cause no little annoyance and financial loss before the theft is discovered. Similar risks, however, are continually assumed by the telegraphing public, for the advantages gained are supposed to outweigh the objections, and for the sake of cheapness and convenience, alleged improvements of this character are encouraged.

Although auxiliary district telegraphs afford facilities for the accommodation of regular customers, they have not provided for the wants of the transient patron, beyond the limited conveniences offered by call-boxes placed in hotels, stores, etc., which are to a certain extent accessible to the public. By an invention recently patented it is proposed to provide a system which will not only serve such a purpose, but also act as a practical substitute for branch offices in many cases. In addition to the ordinary call-box he provides a sounder which with other similar stations on the same circuit is connected with a central office. The object of this sounder is to attract the attention of people in the immediate vicinity to the fact that facilities for telegraphing are at hand. The sounders on the circuit are continually vibrated by an automatic circuit-breaker at the office (which may be a break-wheel provided with the Morse characters), and kept in continuous motion by an electric motor or similar device. The clicking of the sounder having attracted the attention of the by-stander, he finds at hand the necessary message blanks, and possibly other writing material, also instructions for the proper manipulation of the call-box. He is supposed to pull the box before writing the message, which will allow sufficient time for the arrival of the messenger upon its completion. If a proper understanding of the rates can be arrived at, and the exact change supplied, the transaction may be com-







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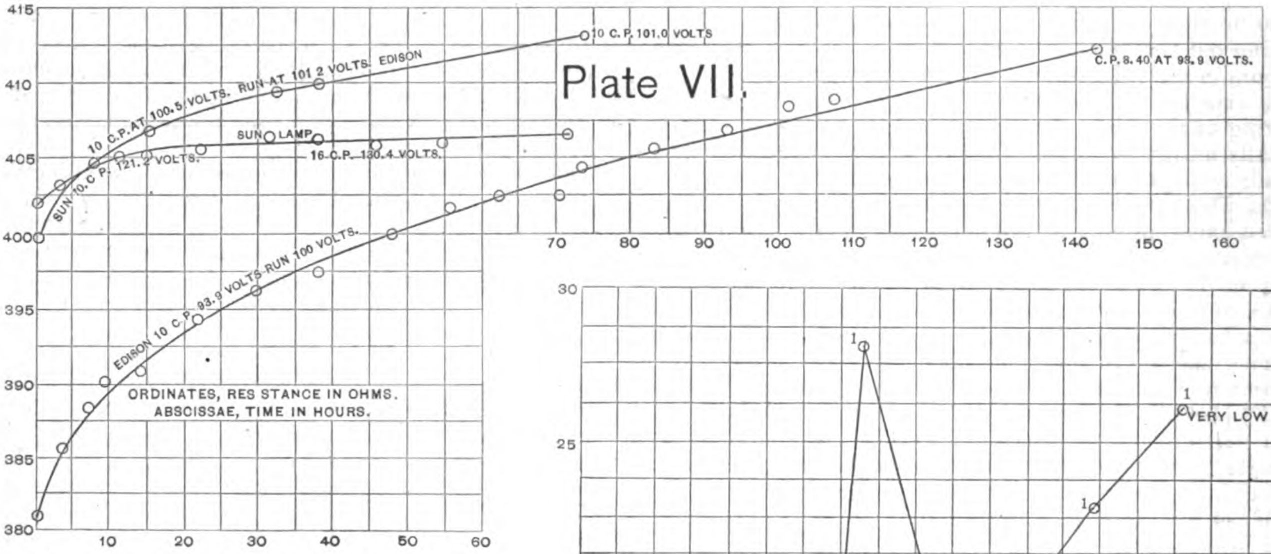
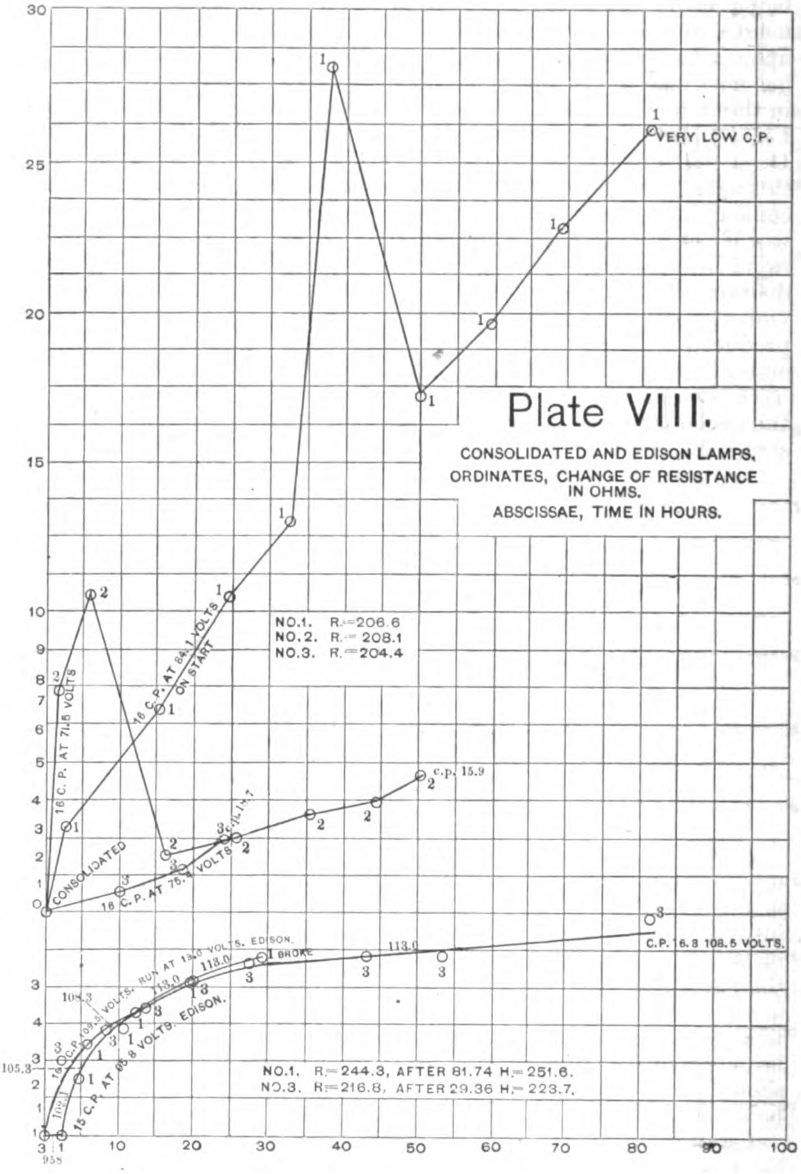
pleted on the spot. An arrangement of this kind is not likely to become a substitute for the ordinary branch office for the reason that if a messenger cannot be summoned within five minutes at least, it will not prove to be a satisfactory arrangement, consequently the districts should properly be as thoroughly covered as under the present system.

SOME CONSIDERATIONS REGARDING INDUCTION.

BY DAVID BROOKS.

ALTHOUGH Henry made known the existence of induction before the magnetic telegraph was brought into use, it was generally considered by practical men to be a myth, so far as concerned the operation of the telegraph. Varley and Stearns found it an obstacle to the successful working of duplex apparatus, and counteracted its effects by means of electro-magnetic coils and condensers. Edison was afterwards compelled to grapple with it in perfecting some of his telegraphic inventions. In the year 1868 the Prussian and French governments put up a couple of international wires between Berlin and Paris to be worked by the Hughes apparatus, and it was found that when the currents were intermitted upon one of the conductors a disturbance was produced upon the other. All of the leading electricians in France held a consultation for the consideration of the phenomena, and it appears by the records that they were about equally divided as to whether it was the effect of induction, or of actual lateral conduction. Extracts from the French journals found their way into American prints, a case in point being the *Journal of the Telegraph*, edited at that time by Mr. James D. Reid. M. Abel Guyot, secretary of the Commission d'perfectionment, communicated with me in reference to the phenomena, and as the disturbances took place in clear weather they were finally decided to be the results of induction. The discussion was participated in by Professor Hughes, Guyot, Blavier, Gavarret, du Moncel and others. While this interesting controversy was progressing similar demonstrations were observed upon the two wires put up along the Union Pacific and Central Pacific railways, between Omaha and San Francisco, and when the atmosphere was very clear and cold, producing a high state of insulation, it was found impossible to work more than one wire. These disturbances occurred only during clear cold weather. For months repairmen might have been seen on the rear of every train hunting for crosses which they never found in the form of actual contacts. The trouble recurred, however, with the appearance of the first favorable weather. Mr. F. L. Vandenburgh and General Stager communicated with the writer in reference to the matter, and being familiar with like results under similar circumstances between Berlin and Paris, I came to the conclusion that the troubles were caused by induction. The entire subject, so far as the Western Union Telegraph Company was concerned, was referred to headquarters at New York, where it was decided that the whole difficulty arose from defective ground connections, the iron railway tracks being used for that purpose. In accordance with this theory some very large copper plates were shipped to Omaha and Salt Lake City to be used for earth connections in place of the railway track. Of course, the substitution of the ground plates failed to remedy the difficulty.

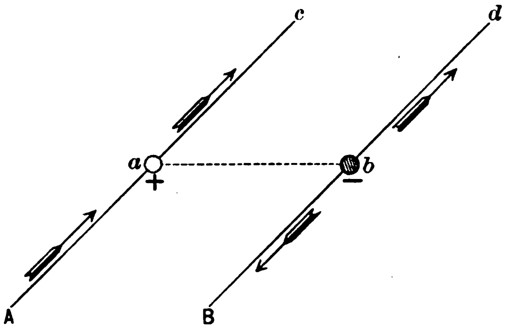




Induction can only be produced, or at least developed to its greatest extent, by very high insulation, whether upon parallel conductors, or in what are known as induction coils.

Noad states that "M. Ruhmkorff brought the induction coil to far greater perfection than it had hitherto attained by paying the greatest attention to the insulation of the secondary wire."

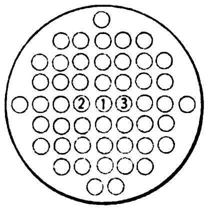
Some years since the writer secured a patent for saturating the bobbin of an ordinary electro-medical machine with insulating material, thereby increasing the effect produced upon the secondary wire to such an extent that it was as much as an ordinary person could endure without drawing out the plunger. The bobbin was immersed for 24 hours in melted paraffine at a temperature of 300° F., which expelled all the air and moisture from the cotton covering of the wire. I exhibited this improvement experimentally as applied to machines from different makers, but as their coils produced all the effect desired, by withdrawing the plunger, they could see no advantage in the increased effect produced, and consequently the patent has lain dormant. A coil so treated, however, is capable of being made in a much more compact form and with less length of wire. When currents are rapidly intermitted upon a telegraph conductor, a neighboring parallel wire becomes charged in the same manner as the secondary wire in the induction coil. During the Centennial exhibition, I laid a short cable from the outside of the grounds to the Department of Public Comfort. One of the conductors in this cable was used for the Edison automatic system, in connection with a wire to New York, and as many as 1,000 words per minute were transmitted through it. The very rapid intermissions of the current charged the other conductors of the cable to such an extent that they gave out a violent shock upon being touched, and these effects were produced at either end of the open wire, but had the two ends of the wire been brought together the discharge would have been double the intensity. In the central portion of the secondary wire there is a point where the tension is at zero. Mr. Preece shows this by the following diagram:[1]



One would suppose that if the insulation at points *c*, *d* was lowered the inductive effect would be increased, but it is not for the reason that the induced current goes to the insulator itself in proportion to its becoming a conductor, or losing its insulation, and consequently is not shown upon the parallel wire. The same effect is produced at the ends A and B; therefore, inductive disturbances to be developed in a high degree require high insulation. It is influenced largely by other considerations and circumstances. There should be no other conductors in the neighborhood, as may be demonstrated by the following experiment:

Let it be supposed that in the following diagram, an astatic galvanometer be attached to conductor number 2 in a 50-wire cable 500 feet long. The galvanometer with its conductor being simply attached to earth, we charge number 1 with a battery of 100 cells.

In an actual experiment as we charged number 1 the galvanometer on number 2 produced a deflection of 130 divisions. It makes no difference upon which end of the conductor we place the galvanometer the effect is the same, and the current going from earth into the conductor number 2 is the same; that is, of opposite polarity to the battery current. We have then a simple Leyden jar arrangement of positive and negative electricities, and produce what is familiarly known as the static charge. The experiment being repeated with number 3 conductor, also to earth, the change produces a deflection on number 2 of but 90 divisions on the scale. We then connect another to earth, and the charge produces a deflection of but 70 divisions on number 2. As we connect the remaining wires successively to earth, the effect upon number 2 is gradually reduced until as the last of the wires is attached the galvanometer needle is moved but 4 divisions.



The foregoing experiment shows how the inductive effects are lessened as neighboring conductors are multiplied, and shows why it was that with additional wires attached to the poles on the route between Omaha and San Francisco the annoying disturbances either disappeared altogether, or ceased to be of sufficient effect to prevent their being used to their full capacity.

Up to this point merely the general principles of induction have been touched upon. Since the advent of the telephone, induction has been an important factor in electrical work, and all of the laws laid down as regards electrostatics seem to be set at defiance. The inductive effect is also found to be much more pronounced upon overhead telephone lines in clear cold weather than when rain prevails. If we take 100 telephone wires strung upon a line of poles, the wires arranged upon 10 cross-arms, each carrying 10 wires, one foot apart in each direction, we have 100 conductors occupying a sectional space of 100 square feet. If these wires extend one mile and are used exclusively for telephone purposes, we observe very marked inductive effects. By using insulated copper wire we may bring these 100 conductors within a space of one square inch. The law of inductive effect between wires is laid down by the authors of the present day as being inversely in proportion to the distance by which they are separated by insulation. Now, in the case of the telephone cable, the conductors are 14,400 times nearer each other than they are when they are in the shape of iron wires strung on poles, and the inductive effects should be 14,400 times greater, but we all know that they are not. In the instance of the pole line we use air as the insulator, which has the least inductive capacity of all substances, Fleeming Jenkin giving gutta-percha over four times, and paraffine twice that of air. It would seem that the inductive disturbance in telephone practice is more of a question of acoustics than of ordinary electrical laws. I know from experiment that cotton or any of the textile materials saturated with paraffine has a much less electrostatic capacity than paraffine itself, and that cotton-covered wire when saturated with oil has much less electrostatic capacity than when saturated with solid paraffine. I can give no reliable data excepting that the more compact the cotton covering and the less oil or paraffine absorbed by it the less the electrostatic capacity. In experimenting with these materials I am frequently reminded of a patent issued to S. F. Van Choate, November 9, 1869 (No. 96,641), in which he proposed to obviate the effects of retardation by clothing the wire with a dry textile covering before the insulator is applied.

The following is an extract from his specification and claim:

Having selected a conductor of suitable size and metal, I proceed to cover it, first with a fibrous wrapping of clean silk, cotton or other equivalent, by winding or plaiting the same upon its surface in such a manner as to form a continuous interposed protection against contact of the wire with the gutta-percha or other preservative, protecting, or insulating material, after which

1. *Journal of the Society of Telegraph Engineers*, vol. iv., No. x., p. 68.

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I apply over the fiber a layer or coating of gutta-percha or other suitable substance or material, and otherwise protect said fiber and its enclosed conductor as may seem proper.

The objects intended by interposing a coating of clean fiber between the conducting wire and the insulating or protecting material may be briefly stated.

The electrical current which is found to be more or less retarded in case the conductor is covered directly by gutta-percha, asphaltum, or other gummy, bituminous or greasy substance, is, by the interposition of the clean fibrous cushion, saved from such retardation.

I claim—

1. A conducting cable for telegraphic purposes, in which a layer of clean, dry, fibrous material is interposed between the conducting wire and the insulating coating in the manner and for the purposes set forth.

Sound is very much deadened by the interposition of liquids. Had the late explosion at Hell Gate been above water, heaven only knows who would not have heard it; as it was, however, people standing but a short distance away heard a comparatively slight rumbling sound made more appreciable by the accompanying vibration of the earth.

One of the most interesting papers ever written upon induction so far as it affects telegraph wires, is that of Richard S. Cully, which was read before the Society of Telegraph Engineers, February 24, 1875. The paper is not only instructive in itself, but the discussion which followed was exceedingly interesting, and was participated in by Messrs. Preece, Latimer Clark, and Adams. Mr. Cully showed by chemically prepared paper that inductive disturbances between wire and wire were far greater on overhead than on underground lines, and gives the substance of his experience in the following words:

"As has already been stated, no inductive action could "be traced between wire and wire in the underground "pipes between the central station and Paddington, al- "though they are four miles and 457 yards long."

* * * * * * * *

"Nor is there any record that induction between wire and "wire was noticed on the buried wires formerly existing "between London and Liverpool."

Mr. Latimer Clark stated "the first and obvious consid- "eration is that we should place the wires (referring to "overhead lines) as far apart as possible, and mix them "about one among another so that no two wires run par- "allel for any great distance."

"Between London and Liverpool, a distance of some 210 "miles, eight underground wires were laid in 1853. When "they were first laid down they were in excellent order. "We made a great many experiments on the effects of in- "duction between wire and wire, and with the instruments "we then had in use we were quite unable to perceive any "induction from one to another. Even when we "charged four of the wires suddenly with a strong battery "power and put our receiving instruments on the remain- "ing four we could not get any sensible discharge."

All of the recognized insulating materials are affected by temperature. The insulating property of gutta-percha is a hundred times higher at + 100° F. than at the freezing point. India-rubber, paraffine, rosin, glass, and every solid substance of an insulating nature is affected by changes of temperature in the same way, but not in so marked a degree. Textile covering, however, like cotton, flax, hemp, jute and manilla show entirely different results. These materials in a natural stat ma y be classed as conductors, but a cable or group of wires insulated with cotton at a temperature of + 300° F., when all moisture is expelled by heat, shows an enormously high insulation, and tests higher in that condition than when immersed in oil at a temperature of + 75° F., and although oil may be said to be affected to half the extent of gutta-percha by changes of temperature, a cable insulated with oil and cotton combined is very slightly affected by such causes, and the more compact the textile covering the less oil absorbed, hence the less affected by change of temperature.

The change of temperature in this climate can be said to range from 100° F. to zero. Under ground the conditions are different; the temperature of water from the hydrant varies between 80° at midsummer and 34° in winter in Philadelphia. As before remarked, inductive disturbance is much more apparent in clear and frosty weather than during rain or under the influence of heat of summer.

Moderately low insulation is the best condition for automatic telegraphing or telephonic operations. But to fix a proper medium to avoid induction is difficult.

Mr. Preece has stated to me that a megohm per mile is better than a higher degree of insulation as regards automatic or high speed telegraphy, and the same law applies to telephone service.

Retardation, which is so often harped upon, is the result of too high insulation. If the conductor has a moderate leak from beginning to end, this impediment does not show itself. Although it is desirable to have the insulation as high as possible when gutta-percha is used, because the higher the insulation the longer the life of the material when used under ground, the insulation can be reduced to a suitable standard for rapid work by putting in artificial leaks in the form of high resistance coils connected to earth at the way stations along the line. Such artificial leaks are placed upon underground wires in Europe to overcome this difficulty where the insulation is too high.

The London *Electrician* of Dec. 4, 1885, gives an account of a telephone line between Paris and Rheims, a distance of 217 kilometres, or say 150 miles, and states that "conversations were held with sundry public functionaries at Rheims whose voices were heard with perfect distinctness," and gives other instances of long-distance telephoning, and adds: "In every case the wires were underground. Had they been overground or submarine the result would have been different."

PRIDE vs. LABOR.

BY C. C. HASKINS.

There is an old and trite saying, which dates as far back as the expulsion of two characters well-known in history from a certain garden, which has made very many of their descendants in every generation extremely unhappy, inasmuch as it entailed upon them the necessity of earning their daily bread, while a favored few, either fortunately or not, are comparatively free from the law's compulsive requirements.

Unfortunately for man and womankind, this unevenness of distribution is productive of envy—of a sort of mental dyspepsia in the less favored, and the large majority of civilized humanity is inclined to ignore honest labor as something at least humiliating, if not positively degrading.

While this feeling is everywhere apparent in the sterner sex, the social law which points out the male as the breadwinner for the family, and thus to an extent enforces obedience to the divine law, circumstances occasionally require the gentler sex to bear a part in the support of the individual or the family.

Here pride asserts its royal sway with even more severity than with the male portion of community. Society regulations and education lead the female sex to consider the chief aim in life from a far different standpoint The mother looks on her female offspring as a plant which eventually is to be cared for and protected, cherished and supported by the strong hand of some man who will thus acknowledge and repay the debt of lasting gratitude he owes for the inestimable gift of a wife from the arms of the loving mother. From childhood this embryo wife and mother is schooled, directly or indirectly, by precept, by the reading of trashy literature, to despise honest labor, to anticipate a life of indolent romance, and to expect a posi-

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tion where in the future she may reign a queen, or at least a princess in her circle.

Now, with all this as the groundwork of a future life, when misfortune renders actual labor necessary to a decent support, all the fictitious, roseate-hued clouds dissipated, there still remains unfortunately, an overweening pride which dictates, in accordance with a fear of what Mrs. Grundy will say, that something highly respectable must be sought as a means of livelihood; and in this selection respectability as they deem it, is made subservient to matters of far more importance.

Said a telephone employé, who would have blushed with shame to have been called anything but a lady operator: "I know I am only getting five dollars a week, and I could earn much more at something else and have my own evenings—but what sort of hands would I have ?"

The Almighty has not made us all equally capable in any one direction; but each may by application excel in his or her line. There are female employés in mercantile establishments who receive more pay than half a dozen sales-ladies. One is now in the mind of the writer, in charge of a department, who receives and is worth to her employers, $3,000 per annum. But all sales-ladies cannot—the majority of men can not hope to attain positions as lucrative as this, though they may by studious application reach the summit of their particular callings, provided the original ability has been given them at birth. There is actually no other limit.

No man, no woman has the moral right to demand or expect from an employer more than the actual equivalent of services rendered; and it is a serious detriment to the morals of the community—it is a positive wrong to demand it, and as positively a moral crime to belittle the abilities which are God-given, by ignoring the mental or physical application necessary to success.

There are plenty of notable examples found in nearly every department of learning and labor, which show what results proper mental training may accomplish.

The wife of the late Count du Moncel was not only well-read as an electrician, but was a writer as well. The wife of a state botanist in New England was her husband's constant companion and co-laborer. In a western city the wife of an enthusiastic scientist has contribnted an immense amount of information on a branch of natural history of which they together have made a specialty—spiders. Mary A. Treat has taught the world far more than was before known of that class of plants which depend upon animal life for existence. The inventor of the beautiful paper dolls which every woman in the land has admired and commended, was a lady, who compelled the world of merchants to purchase her manufactured articles, and is to-day at the head of a lucrative and extensive business in that line of art. Another, driven almost to desperation by necessity, is earning a fair competency by carrying on the manufacture of chicken pies for ladies' restaurants.

These are but a few of the many instances which might be noted. In the field of manual labor the examples are far more numerous. Under the homestead and pre-emption laws there are to-day many—very many ladies who are making more than comfortable livings by following the rôle of farmers, doing all the work, or at least superintending it; holding the plow even, hoeing, planting and harvesting, and fast becoming property holders in the far west. Nor is this sort of thing peculiar to the west. In a township in western New York, more than thirty years ago, misfortune overtook a family which was one of the highest social rank, and of all the girls, some five or six in number, one announced her intention of assuming her deceased father's place at the head of affairs. She went from the piano to the field. She marketed all the produce of the farm, superintended all the work, yet never stopped to think "what sort of *hands*" she had. Through her exertions the younger children were schooled, the entire farm changed into a market garden, the debts of the place paid off, and the property left clear. In a conversation with the lady—for she was never anything but a lady, despite her hands—she told the writer she had never had time to be married—in fact, she forgot all about it from the day when she became a farm hand.

There are plenty of openings for those who would be more than mere hewers of wood and drawers of water—plenty of room upon the top shelf for all who will climb, either men or women, ladies or gentlemen.

ELECTRIC CARS FOR THE EAST RIVER BRIDGE.

BY FRANK C. LOCKWOOD.

The morning of Saturday, December 5th., witnessed the first serious accident on the East River bridge railroad since the establishment of the passenger service. Prior to this, casualities of a more or less trifling nature had occurred, but at last the venturesome passengers discovered for themselves, and with practically the same results, what Jack and Jill ascertained long ago. It is easy to go down hill, and cracked crowns, mangled limbs, and jarred nerves are necessarily the sequence when the descent is too rapid and the stoppage violent. A double collision was caused near Brooklyn because the "grip" belied its name and did *not* grip the cable. The hand-brakes were applied, but the rails being wet, the wheels slipped, and the train of two cars went rapidly back down the grade toward another train it had preceded at a headway of 1½ minutes. The second train, whose conductor had noticed the danger, also began to return toward Brooklyn when the cable was released from the grips, and, gathering momentum, crashed into a third train, partly wrecking several cars, and seriously hurting a number of passengers and train-men. The first train then came up and collided with the second, but fortunately but little damage was done this time. The end of the chapter of accidents has probably not yet been seen. The bridge officials cling to the grip that refuses to cling to the cable, and are as confident as were the men of old of whom Æschylos, the tragic Grecian bard, sang,—

"Waxing o'er confident,
In cables formed of many a slender strand."

There are other dangers to which passengers and even pedestrians on the bridge are exposed. An evening journal has stated one of them. The cable may snap asunder, and as its velocity is ten miles an hour, a break would certainly be attended with disastrous results. This danger, notwithstanding the breaking of one strand of the cable as recently as Sunday, the 20th ult., may seem remote and almost improbable to some, but the other noted is surely a constant menace to the safety of travelers. The question has suggested itself to many, and is particularly germane at this time—why should not electricity be employed to move the trains over the bridge? It is, of course, well known that there are, in addition to the use of storage batteries, two familiarly known systems for electric locomotion ; one, the electric motor to draw the train after it ; the other, to place a dynamo in or under each car. Either is preferable to the cable system as at present managed. There are some difficulties in the way of the adoption of either the Daft or the Edison system ; they are perhaps insuperable where the former is concerned. An engine heavy enough to draw several cars would be too heavy for the bridge structure ; the strain would be too great at one point. On the other hand, a smaller locomotive could perhaps draw only one car, and this, even with the headway reduced to a minimum, would obviously not accommodate the crowds that travel between the two great cities during the morning and evening hours. In the case of the electric *car*, the conditions would be different. A dynamo under each would not only propel its own vehicle, but if necessary, several additional coaches. The obstacles in the way of the adoption of this plan do not seem to be

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supreme. The insulation of the tracks, opinions to the contrary notwithstanding, would not be perfect. The rails rest upon wooden ties, which, in wet weather, would of course, allow some of the current to escape, but, all things considered, the leakage would not be great; certainly not greater than on other elevated structures or surface roads. The cost of making a change is perhaps to be considered, although when life and limb are in the balance, lovers of humanity would tell us that expense should never be considered. The first cost would doubtless be quite an item, but, the new system once established, the expense of running the trains would probably be 25 per cent less than at present. A change must, of necessity, soon be made. The traffic is steadily increasing, and the facilities for safe and rapid transit must be correspondingly augmented. Shall electricity cut the Gordian cable and solve the problem?

THE INVENTIONS OF PROFESSOR HUGHES.

At the anniversary dinner of the Royal Society on the 30th of November, the president, Prof. Stokes, mentioned the presentation of the royal medal to Prof. Hughes for his electric and magnetic researches and for the invention of the microphone and induction balance. The recipient of this well-deserved honor made the following highly interesting reply to the president's remarks:

Mr. President, my Lords and Gentlemen—I cannot hope to find suitable words to express my thanks for the kind manner in which you have responded to the toast proposed by our president, Prof. Stokes, nor sufficiently thank him for the flattering terms in which he has mentioned my researches.

The numerous experiments which led me to the invention of the microphone, are based upon the discovery I made of the remarkable property of loose electrical contacts.

If we make a bad joint or loose contact in an electric conductor, we find that not only do these disjointed conductors vibrate in unison with the atmosphere, but in vibrating they produce an enormous variation in the strength of the electrical current. And if we join a telephone in circuit we find that every word spoken to the loose contact is repeated with absolute perfection.

An equally remarkable fact is the reversibility of the effect, so that a loose electric contact will repeat in sound any variation of current passing through it; consequently, we may speak to one loose contact and listen to a second, when every word spoken to the first will be clearly heard. The greatest power of sound, however, is obtained when used with a telephone, and the augmentation of sound is greatest when the original sound is most feeble.

In order to study the effects of feeble sounds I at first listened to the ticking of a watch, and after making the microphone more sensitive, I was desirous of listening to sounds below the power of the human ear, such as those produced by the walking of a fly. This succeeded perfectly, but unfortunately flies were scarce at the time I was experimenting.

I then studied sounds still more feeble, such as the sounds produced in a copper wire at each passage of an electric current—sounds which no human ear has heard direct, but which by the aid of the microphone are heard as a clear, ringing sound, due, I believe, to molecular motion in the wire itself.

The microphone not only augments feeble sounds, but it will transmit the most complicated sounds of speech and music with absolute perfection. It has also been employed in physical, medical and mechanical researches, and in France it has been of service to humanity in listening through the rocks to the sounds made by entombed miners, and by its indications encouraged the aid which finally saved them.

The molecular sounds which the microphone revealed led me to invent an instrument which should penetrate inside of a metallic body, and reveal any change in its structure. This I accomplished in my induction balance.

In this instrument, induced currents from two separate coils are opposed and balanced with each other, but this balance of current is so sensitive that the slightest disturbance or reaction produced by the introduction of a piece of metal in one of the coils destroys the equilibrium. The amount of disturbance can be measured and the balance restored by the introduction into the second coil of a similar piece of metal, or by an equal reaction.

If we could find two equal pieces of metal, such as coins, they would balance each other, but in practice the instrument is so sensitive, that it points out differences in two similar coins fresh from the mint; or, in two pieces of equal weight cut off the same bar, due either to a slight chemical or molecular difference in the structure of the metal. Any physical or mechanical change, such as that produced by heat, magnetism or strains, are at once declared, and it is particularly sensitive to such changes in iron or steel.

A curious example of its sensitiveness to iron occurred at the Paris electrical exhibition. Elisha Gray, the inventor of the harmonic telegraph, told me that fifteen years ago a small iron filing had penetrated his finger, giving at first some pain, but the filing and pain soon disappeared. He was anxious to know if the filing was still in his finger. I told him to place each finger successively in the induction balance, which he did, and all fingers gave perfect silence, except one. This finger, however, immediately acted on the balance, producing loud sounds, and this finger proved to be the one which had been injured by the filing. So there could be no doubt that the filing still remained after a period of fifteen years.

If we place an iron bar or rod in the coils of the balance, we find that no two portions of the bar are exactly the same, and the slightest flaw, strain or crystallization of the iron is at once detected. Now, if we could apply this method to locomotive axles, we should be able to detect, in advance, any defect, and thus prevent the numerous accidents which occur on our railways from this cause. At present we cannot do this without first detaching the axle from the locomotive, but I have hope some day of finding a modification of the balance which will overcome this difficulty.

The electric sonometer aids the induction balance by comparing sounds from an absolute zero to any desirable extent, and it has been found most useful for measuring the power of hearing in those partially deaf. To cite a single example: Dr. Richardson, F.R.S., has lately published an account of a youth who had been very deaf for many years. On being observed by the aid of the sonometer, the sonometer indicated that the cause of deafness was that of a solid obstruction, and upon operation a stone or pebble was found in the ear, which had been there unsuspected since childhood. On the removal of the pebble, the hearing was immediately and permanently restored.

I will not detain you by speaking of my researches in electricity and magnetism, nor of the many remarkable effects of the microphone and induction balance, but I am proud to say that all these instruments and researches were first presented to the world through the proceedings of the Royal Society.

ELECTRO-PNEUMATIC CROSSING GATE.

A new crossing gate is being perfected by the Union Switch and Signal Co. of Pittsburg. It consists of a horizontal bar from which depend numerous short cords, having weights attached at the ends. This arrangement prevents damage being done either to person or vehicle, in case it is suddenly lowered. The gate is moved pneumatically; the valves regulating the admission of the air are normally kept to their seats by its pressure, but are forced off by a spindle drawn down by electro-magnetism.

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ABSTRACTS AND EXTRACTS.

DYNAMOS AND SHIPS' COMPASSES.

When the electric lighting of a ship has been determined upon, the position of the dynamo is selected, but no thoughts have been given to the probable effect on the steering or other compasses, nor has much notice been taken of the effect of the strong current passing in an adjacent wire. In cases where the vessels are old, the best space has to be taken, there is no help for it, but in new ships it is easy to find a proper place for the dynamo and its engine. The choice of position for dynamo, so far as ships of the Royal Navy are concerned, is limited. There are no unappropriated spaces in a man-of war, and the question of lighting had not been considered when the ships were designed and built. There is a choice of two or three places, none of them being very good. The simple fact that the accident of position, the separation by distance of the dynamo from the compass, and the interference of iron decks, has prevented anything in the way of attraction being noticed, and wires not being permitted near the steering compass, no result having appeared, no attention has been given; but how so had it been otherwise? As we are aware of such a case, and in view of some remarks made recently in a paper by Mr. Jamieson on "Electric Lighting for Steam Ships," we call attention to the subject.

Speaking on the paper itself and on its various points, Mr. H. J. Joel appears to have his attention directed to this point, for he says: "The magnetic action of the dynamo machines, and also the action of the electrical currents in the wires in the ship's magnetic compasses, had not yet been referred to." Mr. Hall, of the P. and O. Co., stated that the ship's compasses were not affected by the strong currents passing through the electric light cables. Mr. Jamieson himself remarks: "The explanation was this: The wires being underneath the iron or steel decks, the magnetic effects were shielded from the compasses placed above deck, in the same way that the delicate magnets inside Sir William Thomson's marine ironclad galvanometers were shielded from outside magnetic influences. Due precautions were taken to keep the wires sufficiently far away from the compass, if at any time they had to be brought up above deck."

In the case of a large paddle-wheel steamer, built (one of four) for fast passenger traffic, when it was determined to thoroughly overhaul and make a new ship of her, it was also decided to light her with the electric light. This was done, and the dynamos and everything being tried, the light was pronounced a success; this was before she left her moorings in the dock. However, when she went out on the unofficial trial trip the vessel answered, but when a display of the electric light was required and shown, it was found that the compass needles were fixtures, and there must be something wrong. This was found to be due to the dynamo being placed in such a position and so closely under the steering compasses on the bridge that its magnetic effect was strong. Of course, this was subsequently remedied. In most ships, room can be found generally on the engine bed-plate, or some place in the engine room, but in this case all the starting arrangements were on the deck level, and this was the place selected. A similar case may not occur again, but as it has once happened, there is no reason why it should not occur again in the future. It has, therefore, been to show that there is danger to ships' compasses that we have made these remarks.—*Mechanical World.*

COMMERCIAL ADVANTAGES OF THE ARC LIGHT.

Sir James Douglass, and many other disinterested observers of the course of events, have for some time recalled electricians to a sense of the blunder they commit in devoting so much attention to the incandescent lamp and neglecting the arc light. It is notorious that the end and aim of incandescent lighting was simply to supersede gas. The extent to which this result is likely to be achieved is now pretty well understood. Electricians themselves are willing to admit that they cannot compete by means of incandescent lamps with gas at its present cost. The arc light, on the other hand, is susceptible of application for many purposes at a marked economy as compared with gas; and it is undoubtedly suitable for use in many places where gas cannot be obtained.

The older arc lamps brought themselves into disfavor by their unsteadiness; but this has, to a great extent, been remedied by improvements in the carbons, and by not expecting too much light from the power available. Arc lamps are still rather more liable to sudden extinctions than are incandescent lamps; and this failing will always cause them to be distrusted for street lighting and the illumination of large buildings frequented by the general public. On the whole, however, the field for profitable arc lighting is wider and more promising than that remaining for incandescent lighting. For many purposes there is no comparison between the arc and any other kind of artificial light.—*Journal of Gas Lighting.*

PNEUMATIC TUBES IN GREAT BRITAIN.

A very large increase in the number and extent of the pneumatic tubes of this country was necessitated by the transfer of the telegraphs to the state, and subsequently a greater increase accompanied the removal of the central station, in Telegraph street, to the new general post-office, and now a further increase in the number has been rendered necessary by the anticipated increase of traffic due to the "six-penny" telegrams. The following particulars, compiled from an official source, are not without interest: In London there are 78 tubes, of a total length of 28 miles 775 yards, the largest being from the post-office to the House of Commons (with West Strand intermediate), 2 miles 353 yards. The tubes in London are worked by four engines, each 50 h. p. (indicating 130 h. p. each), condensing, three working and one spare. In Liverpool there are 14 tubes, of a total length of 5 miles 1,076 yards, with three engines, each 30 h. p., condensing, two working and one spare. In Manchester five tubes, one mile 354 yards, with two engines, each 10 h. p., one working and one spare. Birmingham has three tubes of 917 yards, only worked by one 6 h. p. engine. Glasgow possesses six tubes of a length of one mile 1,208 yards, with one 20 h. p. engine. Newcastle one tube, 460 yards, with one 8 h. p. engine, and lastly Dublin has five tubes of a length of one mile 954 yards. The total number, therefore, of these tubes (almost all being of lead 2¼in. diameter) is 112, of a total length of 39 miles 462 yards. To obtain the power necessary to forward and receive the "carriers" containing the messages 14 engines are required, of a total nominal horse-power of 364. There are in addition about 95 shorter hand-worked tubes, which are at various less important places.—*Mechanical World* [Manchester, Eng.]

TRANSMISSION OF POWER IN NEW ZEALAND.

It is reported from New Zealand that a Dunedin electrical engineering firm is carrying out a contract for the transmission of power to run a stamping battery of twenty heads. The scene of operations is a gold mine in the mountainous country some 30 miles behind Lake Waktipu, and the power to run the battery is transmitted from a waterfall in the neighboring valley, straight over a mountain of about 2,000 feet in height, and for a distance of about two miles. The conducting wire is of the same size as an ordinary telegraph wire, but of copper, and is suspended from telegraph insulators in the usual manner.—*Electrician* (London).

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CORRESPONDENCE.

NEW YORK AND VICINITY.

A Deputy Sheriff Preparing to Sell Western Union Property.—The Stock Exchange Strikes the American Cable Stock Off the List.—A Western Union Operator Officiates by Telegraph as a Physician.—The Commission on Electrical Subways.—Electric Lighting in New Jersey.—New Underground Cables for Chicago.—Electrical Dividends.—A New District Company in Brooklyn.—The Delany Synchronous Multiplex System.

THE fact that a deputy sheriff has levied upon some of the property of the Western Union Telegraph Co., has not created that excitement in financial circles which might naturally be looked for. A private citizen would keenly feel the disgrace of having his effects seized for non-payment of taxes, and his neighbors would look upon him as a questionable character. The Western Union authorities, however, naturally object to being taxed in each state for the entire property of the company, and this is claimed to be the principle at stake. Should the president pursue the same policy as has been adopted in a similar case by the Singer Sewing Machine Co. at Elizabeth, and close up the New York office for instance, there would be music in the air. The judgment against the Western Union company amounts to $132,812, and after taking an inventory of his stock of electrical machinery, the sheriff is expected to proceed with its sale to the highest bidder.

The following is the official announcement at the Court House, signed by Sheriff Davidson.

By virtue of several writs of execution, to me directed and delivered, I will expose for sale at public vendue on Monday, the 28th day of December, 1885, at 10 o'clock in the forenoon, at No. 195 Broadway, New York city, engine, boilers, pumps, telegraphic instruments, dynamo machines, testing machines, &c., office fixtures and furniture, safe, &c., and immediately thereafter at No. 62 New Church street, machinery, tools, &c.

The same company has also had a little breeze with the Stock Exchange on account of its refusal to comply with the rules of the exchange regarding the transfer of shares of the American Telegraph and Cable Co. The result has been that the stock has been stricken from the list of securities dealt in at the Stock Exchange.

For many years, ambitious operators finding that telegraphing promised a rather uncertain future, have devoted their spare time to the study of law and medicine. One of these amateur physicians recently made a hit by volunteering to prescribe for a young lady near Kingston, N. Y., who had taken an overdose of laudanum. Listening to the telegram summoning a distant doctor, he decided that his arrival would be too late to save the patient, so after a hasty consultation the village operator was requested to deliver a prescription, which consisted mainly of simple household remedies with instructions for treating the lady. The details were so faithfully carried out that upon the arrival of the regular physician he pronounced her out of danger, and gave the operator due credit for saving the life. Here is a fine opportunity for a romantic incident from real life to be transferred to some future novel.

The Electrical Subway Commission is busily engaged in the search after the true method of burying the wires. The inventors of different systems are occasionally summoned before them, and Mr. John Thomson, the expert who is thoroughly examining every plan, is preparing to report upon the subject. While waiting for his decision the various inventors might utilize their time by devising grips for the Bridge railway. An office is to be opened for their accommodation at 18 Broadway, and a committee appointed to consider the merits of such grips as may be presented.

In accordance with its promise the Schuyler Electric Light Co., at Elizabeth, started up its machinery on December 12th and the lamps give entire satisfaction. The city authorities propose to give them a trial for street lighting as the citizens appear to be quite generally in favor of such action. The poles which when new were quite conspicuous have been painted a dark green with black bases, and the appearance of the lines is greatly improved.

The city of Trenton is taking steps toward the introduction of electric street lighting, one of the arguments in its favor being the necessity of providing additional improvements in order to prevent the removal of the state capitol to the more enterprising and populous city of Newark.

In New Brunswick some of the property owners have vigorously opposed the erection of poles for electric light lines, and their action has caused considerable annoyance, and in several cases it has been necessary to purchase rights of way before proceeding with the work.

The cables for the Western Union subterranean work at Chicago are being manufactured at the works of the Okonite company at Passaic, N. J. A cable with 62 conductors and 600 feet in length has already been shipped, and another of 92 conductors is now in hand.

The American District Telegraph Co., in this city, has declared a dividend of 2%, the first in five years, which in view of the competition in its field is very creditable to the present management. The encouraging prospect caused a material advance in the price of the stock. The Brush Electric Illuminating Co. of New York, has also declared a 3½% dividend out of the profits of the past six months.

There is a report that the new management of the West Shore railroad has not only reduced the force of operators along the line, but also the wages by about $5,00 per month. This will no doubt eventually lead to a depreciation in the service, but there is a large surplus of budding electrical talent throughout the state which will keep the ranks full.

The People's District Telegraph Co. of Brooklyn was recently incorporated with a capital of $6,000. The general route of the line which it proposes to build is along Washington, Myrtle avenue and contiguous streets.

The Delany synchronous multiplex continues to work very satisfactorily over the Baltimore and Ohio line between New York and Philadelphia, providing six working circuits on a single wire. It being found impracticable to work direct between New York and Baltimore, a repeater has been introduced at Philadelphia to obviate the difficulty.

NEW YORK, December 22, 1885.

CHICAGO.

The City and County Property Lighted with Incandescent Lamps.—The Muddle Created by the Collapse of the Bankers and Merchants' Company.—Amending the Underground Company's Ordinance.—A Triangular Contest over the Areaways—The Tribulations of an Underground Lighting Company.—Pilgrims from St. Louis.—The Milwaukee Complication.—A Multiplicity of Lighting Systems in Chicago.

WELL, our city and our county have made a beginning in the way of electric lighting. The City Hall plant, installed by the Western Edison Light Company, includes the two tunnels, in all about 1,500 incandescent lamps. The plant is run by two Armington and Sims engines, four dynamos, with an overplus of capacity, furnishing the current, and is a grand success.

On the same square and adjoining, the United States Co. has an incandescent plant in the Court House, of about the same size as the city plant referred to. In addition to this, the Criminal Court and jail, the County Hospital, and both the Infirmary and Asylum at Dunning, in this county, have been lighted up by the United States people. These plants are equally satisfactory with the former. In a word, they are models of good, substantial electric light work, and the clerks in both the county and city buildings are immensely pleased at their release from the thraldom of gas.

There have been troubles and troubles about the Board of Trade telegraph lines.

Firstly, the lines were leased to the B. and M. people for ninety and nine years. (Presumably the other got away from the fold.) Then the B. and M. exploded, and L. D. Parker was made receiver of the residue. Then came the foreclosure sale in New York, when Stokes bought the lines and became possessed of a majority of the Board of Trade company's stock, and wanted to enlist their lines in the United Lines companies' army, and to accomplish this the Stokes faction petitioned Judge Blodgett, asking that the B. and M. be compelled to turn over the B. of T. company's property, and also asked an injunction preventing encumbrance of lines, issuing of bonds, or making any leases, and asking the appointment of a receiver. Then on the 28th of November, Charles W. Brega and James M. Ball filed a bill in the Circuit Court against E. S. Stokes and others, asking that a receiver be appointed.

The result of all this was finally to leave L. D. Parker in possession as receiver.

Then, having rested for a short time, the matter came up again on the 14th instant, when Judge Moran was asked to appoint a receiver. The complainant, C. W. Brega, "wants to be permitted to examine the company's books, and to have them kept here in Illinois where by the charter of the corporation they belong. The judge remarked that complainant, even if only holding a minority of the stock, was entitled to have his rights protected, and thought a receiver should be appointed to take charge of the books here, so that they would be safe and all parties interested might see them. He would suggest that Mr. J. D. Hall, his own clerk, be appointed, but hoped the parties would agree on some one. The motion was postponed until Thursday, to enable Mr. Doolittle to consult with his client."

Exactly how the matter will terminate is not, of course, to be known just yet; but Parker is an excellent fellow to hold on, and up to the present writing is ahead, with nearly all the back counties heard from.

There has been lots of skirmishing in the underground business latterly, and it certainly looks now as if we had about reached hard pan.

A proposition was before the council to amend the Chicago Sectional Underground Co.'s ordinance, and during the canvass of the question it was discovered that the city claimed the sidewalks as a portion of the street, and were about to amend the

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charter of the underground people to allow them to go under sidewalks everywhere at will.

The Mikado trio was sung from Fullerton avenue to 39th street, and from the lake to the western limit of the city :

THE AGENTS.

Here's a how-de-do!
If we let 'em through,
By to-morrow they'll be nesting—
If not stopped by loud protesting—
All the areas through!
Here's a how de-do!

THE OWNERS.

Here's a pretty mess!
Might as well confess
Ours is theirs for just the taking,
Through the walls they'll all be breaking.
Then what sore distress,
Here's a pretty mess!

THE TENANTS.

Here's a state of things!
Unless cash it brings
We must fight or make some money.
From their comb we'll tap the honey.
Clip their buzzing wings.
Here's a state of things!

And then the property holders and their agents, and sundry occupants of leased property, assembled and appointed committees. They met again and resoluted as follows :

"*Whereas*, There is now pending before the Common Council of the city of Chicago amendments to the ordinance giving certain private persons and their successors and assigns, the right to use the space underneath the sidewalks throughout the city, subject only to such restrictions as may be made by the commissioner of public works ; and

"*Whereas*, Such space has been since the construction of permanent buildings, and is now used by the abutting property owners with the consent of the city, and large expenditures have been made by said property owners to improve said space and to keep same, the sidewalk above, and the street adjoining in repair ; and

"*Whereas*, The passage of such ordinance may eventually result in ejecting the abutting owners from said sidewalk space, causing the loss to them of immense sums of money which they have expended on the faith of the city, under permits granted by the building department of said city ; and

"*Whereas*, Equity and justice demand that if said sidewalk space is to be granted to any persons or corporations for money-making purposes, that right should be granted to the abutting property owners who have created and maintained the space, as has been the custom as long as Chicago has been a city, rather than make a gift of it to private individuals or corporations who have contributed nothing towards the creation and maintenance of said sidewalk and the space under the same ; be it

"*Resolved*, By the property owners assembled, that we do most respectfully protest against the passage of the proposed amendments, and that a committee of five be appointed to wait upon the committee on fire and water to whom the matter has been referred by the Common Council, and respectfully present the views of this meeting and ask that such ordinance as amended do not pass."

When the smoke of battle had cleared away, and there were more calm deliberations among the hastily aroused citizens, the amended ordinance was finally made to satisfy both parties, and passed. Boiled down to a few words: they now have the right to lay conduits as before, but no right to refuse their use upon proper terms being offered by any company or individual desiring such service. They are permitted to enter and occupy areaways under sidewalks, where owners or occupants are willing. In case such parties refuse, then the commissioner of public works is directed to permit the laying of the pipe or pipes next outside the curb wall of the property across which right of way is refused, or through the alley adjacent to the block where wires are desired.

Bonds of indemnity against damages are required from the parties laying or occupying these conduits or pipes.

The city is to have free use of conduits for all its wires.

The ordinance was adopted by a vote of 31 to 1, and is now in full force.

There are a few plants which in the earlier days of electric lighting here were run to a greater or less extent underground. One of these on the west side, it is claimed, has never had any definite arrangement with the underground people, but the plant has never been interfered with until now. In extending their plant eastwardly they have now came in collision with one of the lessees of the conduit company, and of course there was a chance to put a stopper on a competing company.

At the same time the infringing company claims a right under some previous arrangement with a gentleman formerly connected with the conduit company, which the latter organization denies.

There are some other points in the matter which may make serious complications in the question, but it is hoped and rather expected some satisfactory compromise will be made, so that peace may reign.

As the matter at present stands, the commissioner of public works said that however his sympathies might lean, his duty in the premises was plain, and he would be compelled to enforce the ordinances of the city, by not only cutting the wires, but by prosecution in addition.

Our regular weekly committee to investigate the underground system of Chicago was upon us on the 5th. This time it was a lot of St. Louis investigators from the municipal departments, headed by the speaker of the house of delegates, and included members of both that body and the council, supplemented by representatives from the fire and fire alarm departments, and the inevitable newspaper man—about forty, all told.

They inspected the holes in the ground, and by common consent organized an "experience meeting" at the Grand Pacific, where the various merits and demerits of the Dorsett and the Chisholm-Patterson systems were fully and earnestly discussed.

The meeting listened to remarks from Messrs. Sperry, Dorsett, Haskins, Prof. Barrett, Cushing (superintendent of the Underground Co.), and others. Each of these gentlemen related experiences only, and as there is comparatively but little experience here save with the Dorsett system, they could say but little of any other form of conduit, of course. Still all questions were impartially answered, and occasional digressions as to electrical propositions, mechanical effects, etc., were brought out by cross-examinations.

Both parties were given ample opportunity to advocate their systems, and both were abundantly cross-questioned, and the meeting at one time bore a close resemblance to a police court, so pointed were the interrogatories. Nay, more, a further similarity is shown by the fact that a $30 overcoat belonging to a "looker-on in Vienna" disappeared during the trial, to be seen no more. The party left on Sunday evening without coming to any decision as a body.

The Milwaukee muddle has been amicably settled. Both the underground and the Badger ordinances have been signed by the mayor and become laws. The work of installing the two systems, conduits and light plants, will be commenced at once.

Another arc light system is chronicled as a new arrival. The Ball unipolar folks are arranging to wire a plant on Madison street.

Opperman Brothers are also to set up a 150 incandescent plant, which if successful will be the precursor of a well-backed company to install Opperman dynamos and lamps, with headquarters in Chicago.

The Brush-Swan people are stringing wires for an incandescent plant on Monroe street, which will be completed in a few days.

Chicago will soon be in a condition to show to passers-by almost any variety of either form of lamp, and every form of dynamo, and the danger is that we shall double up on the number of visiting committees from less favored localities.

In my last letter I stated that the Central Union company were giving their telephone subscribers time by the Oram system. It should have read the Chicago Telephone Co.," etc. The Central Union has no lines in Chicago.

CHICAGO, December 20, 1885.

PHILADELPHIA.

The Councils Listen to the Telegraph Representatives.—The Western Union Company Objects to Giving Bonds.—Ready to Bury the Wires if——.—The Rupture Between the Western Union and American District Companies.—Commercial Standing Injured by Refusing to Pay Telegraph Charges.

AT a recent meeting of the Electrical Committee of Councils, representatives of the Western Union Telegraph Co., Bell Telephone company and the Philadelphia Local Telegraph Co., were present to object to the conditions of the ordinance passed October 4th, relative to the laying of underground wires through the city. A communication was read from president Norvin Green, of the Western Union, stating that the provisions of the ordinance and the bond required from the companies were objectionable and could not be accepted and that such conditions as the ordinance contains are asked by the Council of no other city. After the reading of the communication Councilman Hoffman jumped to his feet and excitedly exclaimed : "These companies don't intend and never did intend to lay these underground wires. We gave a patient hearing to their case and gave just what they wanted and now they object to the ordinance they wanted passed."

Mr. Gill, representative of the Western Union, explained that Dr. Green meant nothing offensive, and that the company did intend to lay the underground wires. "We have certain charter rights," he said, "and the bond required by the ordinance may cause a waiver of some of those rights. The company has material on hand to construct the underground wires, for which it paid over $20,000, and it only waits to secure equitable arrangements from Councils."

Councilman Etting said that the ordinance relative to underground wires was passed 1881, and it required all overhead wires to come down in three years, and that the Western Union had never asked for an ordinance to lay their wires underground until last June. Mr. Bentley, president of the Bell Telephone company and the Philadelphia Local Telegraph Co., was asked if his companies would lay underground wires if a satisfactory ordinance should be passed, and he said : "We are now ready to lay

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our wires. As soon as the ordinance was approved we ordered our material to be sent on, but when this question arose we telegraphed the shippers to hold the goods until further orders. We have over $50,000 worth of material now loaded on cars waiting to be sent here. By next summer we would have had all our underground wires laid. It is only in the last three or four months that we have been able to get a cable that would work a mile successfully. We now have a cable that will work from Fourth street to Ridge avenue and we can now lay cables three or four miles long that will work successfully. But no gentleman wants to go on a bond that will forever bind his property, and we think such a bond for $20,000 is objectionable. We have a better system of telephoning in Philadelphia than in any other city in the world. If the city solicitor would alter this bond so as not to waive any of the company's rights the work of placing the wires will be commenced at once." Superintendent Gill said that the Western Union company was prepared to give a good and sufficient bond on the building owned by the company at the corner of Third and Chestnut. Mr. Patton offered a motion, that was passed, that the whole subject be referred to a sub-committee and the city solicitor, with instructions to draw up a new ordinance satisfactory to all parties, and on motion of Mr. Etting it was decided to ask the companies to inform the committee when they would begin the work of laying the wires and when they contemplated completing the same between South and Vine streets and the Delaware and Schuylkill rivers.

The traffic business relations which have for a long time existed between the Western Union Telegraph Co. and the American District Telegraph Co., have been severed, the latter company joining hands with the Baltimore and Ohio Telegraph Co., for the transaction of local telegraph business.

Heretofore the American District company and the Western Union company have operated together under a traffic agreement by which each company gave the other business. The local company exacted a certain sum for transacting the local business of the Western Union, and the latter charged the American District so much for doing general business gathered by it. The agreement expired recently, and the District and Western Union companies could not agree as to the terms of the new contract. Negotiations were then entered into with the Baltimore and Ohio company, which have resulted in the framing of a traffic contract. The local service of the Baltimore and Ohio will be improved by the new arrangement, and it is claimed that the efficiency of the American District service will be in no way impaired.

Suit was brought against the Western Union Telegraph Co., on Monday, by John A. Lynch, proprietor of the Steam Cooperage Works, No 15 Prime street. The plaintiff ordered several carloads of staves from a manufacturer named Adams, in Greencastle, Ind., and requested him to telegraph an acceptance of the order. Mr. Lynch alleges that the telegram was delivered to his residence and the charges, amounting to 60 cents, were paid by him. The following morning the same telegram was sent to his office, but he refused to pay the charges a second time. The company instructed the Greencastle operator to collect there, and Adams, supposing that a man who could not pay 60 cents for a telegram was unable to buy staves by the carload, did not fill the order. Lynch now sues to recover damages sustained through the failure of the negotiations.

PHILADELPHIA Dec. 19, 1885.

BOSTON.

Elevated Electric Railways to the Front.—Lull in the Telephone Rate War.—One Exchange Discontinued.—A Telephone Company Wants $25,000.—The American Bell Company Divides Its Usual Quarterly 3 per cent.—The Lowell Institute Lecture Course.

THE electric railway seems to have struck our vicinity all at once, and all of them at once; first in order to greet us was the Nahant enterprise mentioned last month, the citizens voting to commit themselves to the enterprise. A town meeting has also been held in Winthrop to consider, among other articles, a proposition to connect the town with Boston by means of the Enos elevated electric railway. The following motion, offered by Mr. Underhill, was finally adopted:

"That the expression of the town of Winthrop is favorable towards granting a location to the Enos Elevated Electric Railroad Co., provided that the same is found to be of benefit to the town and that safe and proper conditions can be made with responsible parties under sufficient bonds."

A notice of intention to file a petition to the General Court for incorporation of an elevated railroad company has been recorded in the office of the secretary of the state, for the "Enos elevated railroad.

The names appended to the petition on file with the secretary of state are those of Hon. John W. Candler, M. Denman Ross, Hon. Frederick O. Prince, Hon. Bainbridge Wadleigh and George C. Barrett. These gentlemen ask to be incorporated as the Boston Elevated Railroad Co. Their project is to build and operate elevated railroads on which trains shall be run by electricity. One proposed line is from Scollay square to Harvard square, Cambridge; others from the same or another central point to West Roxbury Park, and to Brookline town hall, and from the foot of Summer street to Milton town hall. Besides these a circuit railroad is proposed, to extend from the Boston and Lowell railroad along the water front to the New York and New England railroad; thence via the Old Colony, Albany and Providence railroad stations, to the Lowell, completing the circuit.

The model they propose using is known as the Riley patent, the property of the Riley Elevated Railway Construction Co., a corporation chartered under the laws of New Jersey. The structure is simple and economical, and from the method of connecting the rails and woodwork thereon the track inspection and liability to accident will be greatly reduced. The system is not in operation at present, but work is about to be begun on a mile and a half section of the Rockaway Beach railroad, and a contract for a ten mile road in Chicago is pending. The plans are said to have been examined and indorsed by Mr. Thomas A. Edison, Stephen D. Field, Leo Daft and Lieutenant F. J. Sprague, and pronounced by them as the best system of an elevated road upon which to successfully apply an electric motor that they have ever seen. The plans have also been endorsed by well-known civil engineers and others. It is the intention to begin at once with a model track of a half mile length in order to satisfy the incredulous by actual demonstration of the feasibility of the plan. What line of road will first be built into the suburbs, if the charter shall be granted, has not yet been definitely determined, but the Cambridge line or that to West Roxbury Park would be perhaps the most likely to be chosen.

Still another elevated project is on foot for the country north of Boston. Mr. H. H. Hutchins has filed a petition to the Legislature for incorporation as the Boston and Somerville Elevated Railway Co., with power to build and operate elevated railroads operated by electricity, from Scollay square through Charlestown and Somerville, to Medford square, in Medford.

Associated with Mr. Hutchins are Hon. Selwyn Z. Bowman, Hon. George A. Bruce, N. W. Bingham, James E. Whittaker, Edward Glines and others, all of whom are prominent citizens of Somerville engaged in business in Boston. The plans of the projected road have not yet been developed and no system either of form or structure or of running cars has yet been determined. These parties propose to own a franchise if nothing more.

The Cambridge aldermen on the 3d inst., had a hearing upon the petition of the American Electric Manufacturing Co., of New York city for leave to erect poles for wires upon Main, Cambridge, Prospect, Harvard and other streets, for the purpose of lighting streets and buildings, the company acting under the Fuller-Wood patent. Another corporation, the Cambridge Electric Light Co., acting under the "Sun" patent, also had a petition before the board, and both companies were represented by counsel and a large number of experts, each claiming that their system was perfectly safe and the other extremely dangerous to the public, and that each possessed better illuminating power than the other. At the close of the hearing, the matter was recommitted to the committee on roads and bridges.

The public, whom the late Vanderbilt dwelt upon so tersely, have quieted down to the condition of acquiescence in the telephone rates.

In some few places the telephones were so reduced by the "kickers," that the company abandoned the whole service, as in Gardiner, Maine, where owing to the number of telephones removed since the advance in rentals, the company discontinued the central exchange office. The remaining half-dozen out of the original 65 instruments will be operated through the Augusta office.

At a meeting of the stockholders of the Inter-continental Telephone Co., held at their office in this city, on the 14th inst., to consider what action should be taken in raising an indebtedness of some $25,000, it was voted to place the matter in the hands of the directors for their action.

The American Bell Telephone Co. go right on declaring their usual 3 per cent quarterly dividends, just the same as though Mr. Secretary Lamar had decided not to bring suits in the United States courts.

Boston is the most prolific city in the Union for lectures and concerts, and thousands derive pleasure and satisfaction from attending them. The Lowell Institute courses of lectures are always interesting and profitable, ranging as they do through most of the sciences.

Mr. Thomas D. Lockwood, well known in telegraphic and telephonic circles, is now delivering a course of six lectures at the Lowell Institute on "The Electric Telegraph and Telephone," each Monday and Thursday evenings, beginning Dec. 7th.

The first lecture was upon "The Genesis of the Electric Telegraph," the second "The Principles of Electric and Electro-Magnetic Telegraphy," the third "The Morse System, with Glimpses of Dial, Printing and Autographic Telegraphy," the fourth "The Expansion of the Telegraph," the fifth is upon "The Telephone," and the sixth will be upon "The Industrial and Commercial Application of the Telephone."

As Mr. Lockwood is identified with the interests of the American Bell Telephone Co., there will be no mistaking his attitude

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on the question of "who invented the telephone." The lectures have been listened to by large and appreciative audiences.

Prof. Chas. R. Cross, of the Institute of Technology has been giving a very interesting series of twelve lectures at the Lowell Institute, on "The Acoustic and Elementary Principles Underlying the Art of Telephony." The lectures are delivered Mondays and Wednesdays, and were begun November 9th.

BOSTON, Dec. 18th, 1885.

WASHINGTON.

The Procession of Government Telegraph Projects.—The Bill for Defining the Status of Military Telegraph Operators.—Incandescent Lighting at the Capitol.—Perpetual Injunction against the Erection of the Western Union Pole Lines.—Judge Hagner, Electrical Expert and Inventor.—The Status of Subterranean Work.—Improvements by the United States Electric Light Co.

THE meeting of Congress has revived the old schemes for government assumption of the control of the telegraph, and with them come new bills for the accomplishment of the same object by somewhat varied means. In the senate Mr. Edmunds has re-introduced his bill of the last congress, and Mr. Cullom has a proposition to buy up all the lines and run them as a government institution. In the House of Representatives, Mr. Anderson, of Kansas, was prepared to present his scheme of last year but left before his state was called. Messrs. Rogers, of Arkansas, and Weaver, of Iowa, being earlier on the list each got in a bill for a similar object. These will doubtless be followed by others before the entire list of states is called through. When they are all in and printed, an outline of their leading features may be interesting.

Mr. Wait, of Connecticut, has re-introduced the bill of the 48th Congress for the relief of military operators during the civil war. The bill proposes to place them on the army rolls, graded in rank according to service rendered, with the right to certificate of discharge, and to stand as other members of the army as to pensions and homestead entry on the public lands. I could find no one pushing the bill, which is a just one, during the last congress, even Mr. Wait was unable to give me any information beyond the fact that a friend had asked him to introduce it and have it referred to the committee on military affairs. Telegraph operators, even if youths during the war, should have learned by this time that legislation, however meritorious, does not go by its own weight. I do not mean to imply corruption, but simply to say that there is so much business that is pressed upon the attention of the members, and not improperly pressed, that other matters are absolutely crowded out of sight. It will require a number of weeks incubation in committee before any of these schemes are brought to the attention of either House. I shall endeavor to keep the readers of your journal advised as to any progress made.

The Edison Electric Light Co. in the senate, and the United States Electric Light Co. at the house end are preparing to show what can be done in the way of incandescent lighting. The latter, owing to the illness of the electrician assigned to that duty failed, to complete the work before the meeting of congress and will take advantage of the holiday recess to put everything in good shape. The Edison lights most of which were put in last winter are giving good satisfaction at the senate end.

Judge Hagner, the legal electrical expert, on the 17th inst made perpetual the temporary injunction granted in May last against the Western Union Telegraph Co., restraining that company from erecting telegraph poles on 7th street. Early in the spring a compromise between the commissioners and the Western Union company permitted the latter to lay underground wires through the heart of the city and thence to the boundary by heavy poles carrying all their northern wires, which would allow the taking down of several miles of air lines in the busiest part of the city. Judge Hagner took the ground that the control of the streets was given to the commissioners so far as to control it for the purposes of travel, and that to permit it to be used in the manner proposed was a step beyond their authority. He however went out of the way to declare underground telegraphy perfectly practicable. In fact he had once invented an underground system himself, while president of the line between Annapolis and Annapolis junction. The Western Union company noted an appeal, but congress will doubtless end the matter by more clearly defining the powers granted the commissioners before the case reaches the court *in banc.*

There is nothing doing just now in the way of laying underground wires. Those that have been laid and are in process of testing give good satisfaction generally. Mr. Miles, superintendent of the Police and Fire Alarm Telegraph, is so well satisfied with the Waring cable of the Standard company that in his annual report he recommends their substitution for the present fire alarm and police telegraph and telephone wires. He asks for an appropriation of $25,000, to "begin" the subterranean system. Col. Wilson, superintendent of public buildings and grounds, is also so well satisfied with the same cables in use in his bureau as to ask an appropriation of $10,500, to bury the remaining overhead wires. Mr. Bryan, general manager of the telephone service in Maryland and the district, is so well satisfied with the working of their elaborate and extensive system of 100 and 50 wire cables, that he has caused to be taken down many hundred miles of air lines that were left standing while the cables were being tested. The Baltimore and Ohio company has had bad success practically with their underground experiments, but Col. Clarke, their manager here, is satisfied they now have the best system of all—the Averell patent. A short section was laid last summer, perhaps one-fifth of the distance from their general office to the depot; in turning a curve the wires which are laid bare in asphalt were drawn in tightening so that in many cases two or more came in contact and the work was suspended. As an offset to this Col. Clarke says they run their wires experimentally through Averell underground wires that were laid three years ago. At that time Gen. Averell laid a prism of asphalt with 70 plain copper wires inclosed. This has been left above ground exposed to the elements for three years—and with the exception of three, near the outside where the covering was forcibly pounded off, the insulation is perfect. The remaining wires have been coupled up back and forth through the prism so as to give about eleven miles of this wire in each of three circuits connecting with Cincinnati and Chicago, on which quadruplex and duplex instruments are worked without trouble. The defect in the proposed route between the general office and the depot will be remedied, and the work completed as soon as the weather is such as to permit the resumption of the work. The Western Union company is equally satisfied with their line of empty pump logs, for under the decision of the court the commissioners have no authority to disturb their air lines, which they continue to use. The heavy and expensive underground wires laid by the Postal company despite the vicissitudes of the company, have worked well with a single difficulty. It has been found in practice impossible to keep the water out of the man-holes. Although made in the form of a solid iron box with the cover set on rubber packing and tightly screwed down, the water will at times get in and ground the wires.

Since the fire in the *Post* building in July last which practically destroyed their plant, the United States Electric Light Co., has made many material improvements, and notwithstanding largely increased expenditures and outlays for additions to its plant the stock has advanced nearly fifty per cent. from quotations before the fire. The building formerly occupied by the Brush Swan Co. was leased, and two Ide engines of 60 h. p. and two of 100 h. p., each with one New York Safety Co. of 100 h. p. have been put in. They also secured a transfer to them of the Thomson-Houston system and are running seven of these dynamos of 45 lights each, which they use exclusively for arc lighting, and two Weston dynamos for incandescent lights. All the wires necessary to be run in connection with the new station have been put underground. The Callender (English) system has been used, and thus far works satisfactorily. These underground wires include a connection with the capitol, where, as stated above, they will do some gratuitous lighting.

This company proposes to light Pennsylvania avenue from the capitol to the treasury, and F street from 9th to 15th. If after a month or two the superiority of electric lighting is not appreciated sufficiently to secure an appropriation to pay for it, the attempt will be abandoned, and the gas company left in possession of the field. The electric light companies frankly admit that our deeply shaded streets cannot be as cheaply lighted by electricity as by gas, but claim to give more lights for the money.

WASHINGTON, Dec. 24, 1885.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICIAN AND ELECTRICAL ENGINEER, 115 *Nassau Street, New York city.*

POWER REQUIRED FOR THE ELEVATED RAILWAYS.

[43.]—"It would be very difficult for an outsider, not an electrician, to form any idea of the feasibility or probable economy of propelling the elevated railroad trains by electricity, unless he had given that subject and particular problem a great deal of attention and calculation."

I quote the above from an article in the March number of the ELECTRICIAN AND ELECTRICAL ENGINEER, by Charles G. Curtis.

It is not my intention to enter into any discussion of this article generally. I should be inclined to make no reference to it nor to the "corrected figures" appearing in the May issue, had Mr. Curtis let bad enough alone and not plumed himself on his accu-

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racy by reference in the November number to Mr. Sinclair's valuable experiments.

It is time that his manifold errors on work done by the elevated road engines were pointed out.

The first article represents the engine as having nothing to do but ordinary traction at a mean speed of 12.5 miles per hour, gives a mean power of 23 horses, and a net consumption of 19 lbs. of coal per horse-power hour.

The next article corrects this by taking into account the work expended in raising the train to its full speed, increases the engine power to 75 horses, and reduces the expenditure to 6.6 lbs. of coal per horse-power hour.

In Mr. Curtis' last letter he "refers to it (Sinclair's work) because it is so satisfactory a verification of the results arrived at by a theoretical mechanical calculation," etc.

Allow me to present a few facts for Mr. Curtis's consideration.

The work done on the elevated roads is expended in three, not two, ways: overcoming the inertia of the train, lifting it bodily from the level of low to that of higher grades, and traction. The proportions of work are very nearly as follows:

Overcoming inertia....	59	per cent.
Lifting..........................	24	"
Traction........................	17	"

Mr. Curtis lost sight of the grades of this road, which require that a train be lifted bodily an aggregate of 282 feet in one round trip. The work so done is half as much again that expended in traction.

The average net horse-power distributed over the entire time of a trip is about 69 h. p. The actual engine capacity is about 185 h. p. per minute. The mean running speed between stations is 14.7 miles.

Mr. Curtis's agreement with Mr. Sinclair is purely accidental, caused by getting his average maximum speed too high, leaving out the work of lifting, about a quarter of the whole, and the element of engine or motor friction.

Some papers will be made public in a few days which will give the methods of getting the above results, and also answering some of Mr. Curtis's queries, why and how shall the elevated roads be operated by electricity?

One of those answers is that the capacity of the roads must be increased independent of the saving in coal expense, although this is perfectly practicable.

"I, for one electrician," and one whose faith in the future of electric propulsion is not so easily shaken, will be glad to soon show Mr. Curtis how this is to be done.

NEW YORK, Nov. 27, 1885. FRANK J. SPRAGUE.

UNDERGROUND TELEPHONE WIRES.

[44.]—I observe my friend, Thos. D. Lockwood, electrician of the American Bell Telephone Co., is out in the last number of your journal at his old business, trying to write down underground wires from which I quote as follows: "Wires centering at telephonic exchanges are not conveniently placed underground, as the retardation due to static induction shows itself on very short lines, and makes the talking very indistinct. This is quite perceptible even on a half-mile line, and is much emphasized when a long line is connected thereto."

On the 13th of November the New York Electrical Sub-way Commissioners visited Philadelphia and examined our system. Ralph W. Pope accompanied them and writes of it as follows:

"Mr. Thomson accompanied by Mr. Palmer of the Brooks company, drove to Kensington, the remainder of the party going to the office of the company 310 Chestnut street, these being the terminals of a line which is about 2½ miles long. The telephone tests proved perfectly satisfactory in every respect when the line was arranged in metallic circuit, but induction was apparent to a considerable extent when the wire was grounded. It is but fair to state that the inductive effects were far more apparent over the regular overhead telephone wires of Philadelphia than they were in the underground wires in either of the cities visited," meaning Washington and Chicago. The first trial was with a metallic circuit composed of No. 22 wire American gauge. In the same inch and a quarter pipe, there were other telephone and telegraph wires working which we showed to the commission by putting a Morse relay on them and approximating the strength of the current on the Morse wires by observing the spark upon opening the circuits, we then tried the telephone wires on a circuit grounded at each end, and Mr. Pope states "Induction was apparent to a considerable extent when the wires was grounded," but the object of this test was to show that under the conditions of strong battery currents in the same pipe, the inductive disturbances "were far more apparent over the regular overhead telephone wires than they were in the underground wires," and to show this we took an overhead telephone from the same building on Chestnut street, to two different subscribers in the neighborhood, but not quite so far from 310 Chestnut street. Now if telephone wires work better mixed up with telegraph wires than the regular telephone service with no telegraph wires in their neighborhood or proximity, what is the use of Mr. Lockwood continually making such statements? Will the commission believe their own senses or Mr. Lockwood's statements in direct violation of the facts. Mr. Pope writes "The telephone tests proved perfectly satisfactory in every respect." Mr. Pope's interest is that of an impartial investigator, Mr. Lockwood does not want the wires to be buried, because it costs a little more than stringing them on house tops. We showed to the satisfaction of the commission that there was no cross talk or eaves-dropping, while the overhead wires were full of it, besides being continually interrupted by breaks and crosses or contacts.

PHILADELPHIA, Dec. 13, 1885. H. C. FREMPT,
Supt. Brooks Underground Conduit Co.

THE RESISTANCE OF COPPER WIRE.

[45.]—The December issue of your journal contains an article by Carl Hering on the resistance of copper wire, which he clearly shows to be a very uncertain quantity. What he does not make quite so clear is that each of the 22 constant values given are not equally reliable, or at least not equally authenticated. Thus it might be inferred that in calculating a table of the resistances of different sizes of copper wire, I happened to employ constant No. 2, but that I might just as reasonably have adopted constant number *n*. After explaining that in various text-books, trade catalogues, electrical journals and work shops, numerous and conflicting—not to say unfathered—values for the resistance constant of ordinary commercial copper wire have been published, he demonstrates that if the mean of such of these values as appear to be about right is taken, and a happy standard temperature selected, the result will be a simple little formula representing the resistance of commercial wire, if you happen to get that kind.

Although 16 sources are named from which the 22 different constants were obtained, authorities for but 5 of the constants are given. Four of these are attributed to Matthiessen (three are quoted second-hand, however), and one to Kohlrausch. The latter's resistance figure is known to be too high. The fourth of Matthiessen's values is published in his own report to the British Association and is taken as the basis of my table.

I presume copper wire can be bought in the New York market with conductivities varying from 50 to 100 per cent. pure copper. What then is the use for a constant for average commercial wire? A lineman who carries a table of resistances of pure copper wire has all that he needs to enable him to determine the properties of any wire that may come into his hands. Reputable manufacturers will tell him that their wire is 98 or 95 per cent. pure copper, and he takes oft 2 or 5 per cent. from the values in his table. If he doubts a dealer's statement, he gets a piece of the wire measured and compares the result with his table. That would have to be done in any case of doubt.

I do not assert that Matthiessen's value is correct, but only that it is the value on which at present there is the most reason to place dependence. I wish some prominent electrician would re-determine the specific resistance of the best Lake Superior copper. Why not the Johns Hopkins university with its splendid facilities? Every wire manufacturer in the country would be glad to furnish the special wire required.

In conclusion I wish to say that I hope Mr. Hering will not think I have criticised him too severely, but I think that in these days of unreliable constants, it should be the duty of electricians to destroy those which are unauthenticated rather than put them in a condition for preservation as stumbling blocks for future generations. GEO. B. PRESCOTT, JR.

Laboratory of Edward Weston,
NEWARK, N. J., Dec. 7, 1885.

LITERATURE.

REVIEWS.

Workshop Receipts: for Manufacturers, Mechanics and Scientific Amateurs (fourth series), by C. G. W. Locke, London and New York: E. & F. N. Spon, 495 p. 8°, illustrated. Price $2.00.

In our review of the third volume of this useful series of publications we called attention to the fact that interest in electrical research tended to lead the investigator into various branches of science and mechanics. Experience soon teaches us that there are numerous processes with which we should become familiar, and it is then that the amateur more especially, may turn to a book of this character with interest and profit. It is well to note right here that the compiler has added greatly to the value of his work by supplying it with a copious index not only of the present volume, but the three which have preceded it. The electrical chapter of the fourth series is devoted to the process of electrotyping, the method being treated in plain and simple language befitting the general character of the work. Following this is a chapter devoted to the similar art of stereotyping comprising both the plaster and the paper processes. Among the other subjects which are fully treated of, and to which the amateur mechanic may occasionally turn his attention are waterproofing, bookbinding, musical instruments, clock and watch repairing, and photography. Appropriate space is also devoted to cooling, freezing and embalming, pumps and siphons, distilling and evaporating, all of which combine to make a valuable book of reference for the workshop, laboratory or home.

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ELECTRICAL NEWS AND NOTES.

JUDGE WALLACE'S DECISION IN THE NEW HEARING OF THE DRAWBAUGH CASE.

After the original decision in the Drawbaugh case rendered by Judge Wallace in December, 1884, the testimony was stipulated into the "Overland" case, further testimony being taken in an effort to sustain the Drawbaugh claims. The arguments upon the new testimony were heard by Judge Wallace at Syracuse, who after due consideration gave the following decision:

United States Circuit Court—Southern District of New York.

AMERICAN BELL TELEPHONE CO. *et al* *v.* THE PEOPLE'S TELEPHONE CO. *et al.*

WALLACE, *J.:*

Since the decision of this case in December last, additional proofs have been taken on the part of the defendants, and by consent of complainants have been presented for the further consideration of the court after argument of counsel.

All the new evidence is cumulative merely. Such as consists of the testimony of new witnesses to knowledge of the existence of Drawbaugh's talking machine prior to the date of Bell patent, is far less persuasive than much which has already been considered and rejected as incredible. Such as is intended to show that the earlier instruments made by Drawbaugh were capable of practical use in transmitting articulate speech is more important. The instruments which were introduced as reproductions of lost originals, representing Exhibits B, F and C, and which were constructed by Drawbaugh, or under his supervision, as accurate productions of the originals, were shown to be practically inoperative. After they had been introduced in evidence, and the expert witness for the defendants had testified that he had found them to be good practical instruments, a test of their efficiency was made at the request of counsel for the complainants, which took place in the presence of the experts and of the counsel of both parties. This test, which was made in 1882, indicated decisively that the testimony of a large number of witnesses respecting experiments with Drawbaugh's earlier instruments, on various occasions in the years 1869 to 1876, was unreliable. While, according to the testimony of these witnesses, the instruments invariably operated satisfactorily upon the occasions of which the witnesses spoke, and no difficulty was experienced or observed by them in the transmission of the messages sent over or heard through the instruments, it was demonstrated by the experiment in 1882 that under more favorable conditions speech could only be occasionally transmitted by the reproduced instrument, and that generally what was spoken, if transmitted at all, was transmitted in a fragmentary or incoherent form. Whether these instruments were, in fact, reproductions or the original instruments, was a question which depended solely upon the testimony of Drawbaugh. But assuming that his testimony was true, and that they were reproductions, it was impossible to doubt that they were the best that Drawbaugh knew how to construct after he had become a much more accomplished electrician then he was when, according to his testimony, he made the originals.

Since the former decision, new reproductions of these alleged originals have been made from the remnants of the originals, supplemented by drawings verified as correct by Drawbaugh from memory, and it now appears that these productions are practical instruments, and fully capable of transmitting articulate speech successfully. It does not appear that Drawbaugh made them or who made them; and no testimony has been introduced to explain the reason of the failure of the instruments made by Drawbaugh to operate satisfactorily. It appears from the testimony of the only witnesses adduced to the point that, upon a comparison of the former and the recent productions, the recent ones are improved in finish and detail of mechanism in respects calculated to improve the efficiency of the apparatus; and it also seems probable that the increased efficiency of Exhibit F the more important of the reproductions, is due to the employment of a new conducting material between the back plate of the cell and the diaphragm of the transmitter, adapted for the adjustment in a mode never practiced by Drawbaugh, and made the subject of a patent to Henry Hunnings of the date of August 31, 1881. The legitimate effect of the evidence is to show that Drawbaugh was very near the realization of the invention if he had really constructed instruments like the Exhibits F, B and C prior to the date of Bell's patent. It does not, however, alter the fact that he was unable to make such instruments at a period long subsequent to the time when he claims to have made them; and in view of this fact the evidence does not tend to materially fortify the testimony of the witnesses who think, or profess to think, that they heard or saw efficient practical instruments in operation at Drawbaugh's shop on the occasions to which they refer. The conclusions that were reached at the former hearing have not been modified, and the decree ordered should not be disturbed.

THE WASHINGTON FIRE AND POLICE TELEGRAPH.

In his annual report to the district commissioners, superintendent H. R. Miles, of the district telegraph and telephone service, presents some interesting facts regarding the improvements of the systems under his charge. Forty-six improved Gamewell signal boxes have been added, and all of the circuits extended, 60 miles of wire having been put up during the year. Including the police patrol service, the district has in use 117 sets of telephones, all of which are rented from the Chesapeake and Potomac Telephone Company. During the year, 151,071 recorded messages pertaining to police business were transmitted over the wires by telephone, an increase of 31,658 over the previous year. As not more than one-half of the messages are recorded, it is safe, the report says, to assume that not less than 300,000 messages were transmitted during the year.

"The telephone," Mr. Miles says, "has become a necessity in all the departments of the district government, answering far better for most purposes than the telegraph. But for police business a good printing telegraph would, in my judgment, be far better, for the reason that accurate printed copies at both ends of the line would be secured, and confidential communications could be sent without any danger of leakage or disclosure en route."

THE PATROL SYSTEM.

"The patrol telegraph and telephone system," the report says, "first introduced in the fifth police precinct, has worked in a very satisfactory manner. During February last, five of the sentry box stations—of the twenty—in that precinct were removed to and put up in the seventh precinct, together with ten new ones purchased for the same precinct, so that the fifth and seventh precincts each have fifteen sentry stations, all of which, in both precincts, amounting to $7,600, has been paid for from funds appropriated for that specific purpose. The patrol telegraph and telephone system for police duty has become a necessity, and should, in my judgment, be extended as rapidly as possible into and throughout all the several precincts."

UNDERGROUND CABLES.

"In my last annual report," Mr. Miles continues, "I stated that the Standard Underground Cable Company had put down certain lines of the Waring cable for trial use by this department, and that so far as these cables had then been tried they had been satisfactory.

"I now supplement that report by the further statement that we have been using the same cables continuously since my last report for both fire-alarm telegraph and telephone business with the best possible results. In fact, we have had no trouble in the use of the conductors, nor has there been any expense incurred in keeping the cables in order. I see no practical reason why all the wires used for fire-alarm telegraph, as well as for general telephone purposes, should not be put underground—if suitable and first-class cables be selected for the purpose.

"I am aware that it will cost a large sum of money to put all the wires of the telegraph and telephone service of the district underground, and would not recommend that it should all be done in one, or even in two or three years. But I am so fully satisfied of the practicability, as well as of the desirability of having them put in underground cables at an early date, that I consider it my duty to recommend that an appropriation be made of $25,000 to begin the work, to include all the wires now in the trunk lines running along D street, between 5th and 13th streets; along 13th street, from D to L; along L, from 13th to 17th, and along 17th street, from L to M streets northwest, including such loops running out from the main lines as may be necessary to reach the signal boxes and other instruments within two or three squares on either side of the proposed route. The laying of good cables on the route proposed," the report continues, "would be a good beginning in the right direction—would remove from the heart of the city a long line of poles, which, if not dispensed with in the way proposed, will soon have to be replaced by new and larger poles—not a desirable thing to do if cables can be substituted.

THE NICHOLSON QUADRUPLEX PATENT.

UNITED STATES PATENT OFFICE.

Henry C. Nicholson, of Kenton, Kentucky, Assignor to the Western Union Telegraph Company, of New York, N. Y.

QUADRUPLEX TELEGRAPH.

Specification forming part of Letters Patent No. 332,550, dated Dec. 15, 1885. Application filed May 11, 1876.

To all whom it may concern:

Be it known that I, Henry C. Nicholson, of Kenton, Kenton county, state of Kentucky, have invented an improvement in electrical telegraphs, of which the following is a specification.

My invention relates to devices for manipulating electrical currents on a single line wire with usual ground connections, so as to admit of the sending of four signals simultaneously, two in each direction, the most that will be required in sending one message in each direction of the Nicholson alphabet, as patented by me in Letters Patent numbered 112,836, March 21, 1871.

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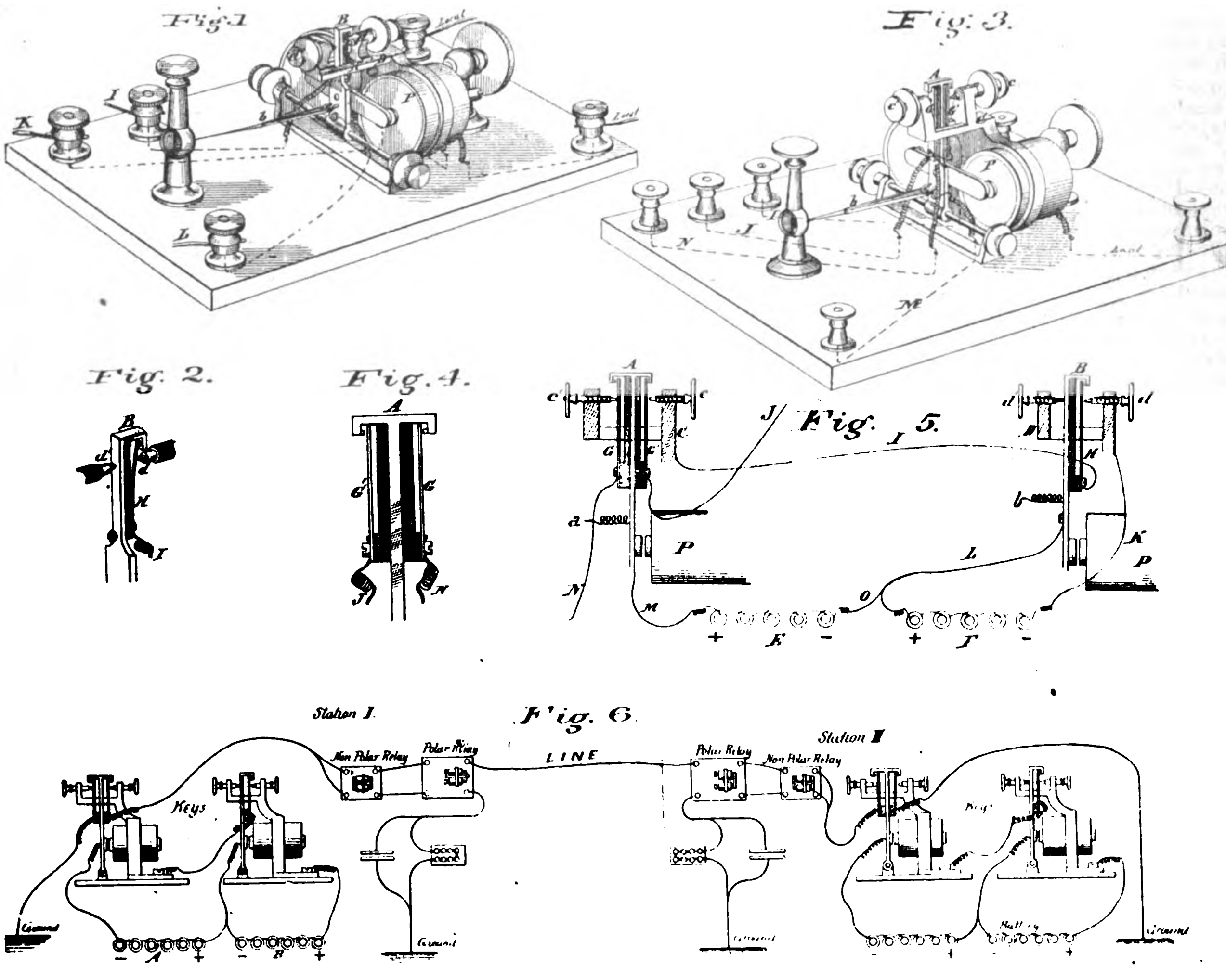
My invention consists, in the first part, in a system of telegraphy of such a construction and arrangement of parts as that by proper manipulation of the currents from a pair of batteries of equal size (the left of which at all times remains in circuit with main line) may present themselves as follows, viz.: plus polarity to line from single left battery when both manipulating keys are open; minus polarity to line from single left battery when left or reversing key is closed; minus polarity to line from both right and left batteries when both keys are closed, and plus polarity to line from both right and left batteries when single or right manipulating key is closed, and thus requiring but two relays (one a polarized relay and the other a non-polarized relay of increased resisting powers) at the distant station to receive the message from even batteries; and my invention consists, in the second part, in transmitting devices, of a key for manipulating the main-line current, consisting of two insulated spring self-contact points and two outside contact-points for the said spring points to play against, the whole acting in different capacities to C of the local relay P. The key B is provided with an insulated spring, H, which plays between the hooked end of the key and the point d in the relay frame D. The whole keys A and B play bodily between the respective points c c' and d d', the latter point, d', being merely an insulated rest. These keys are, as shown in figures 1 and 3 of the drawings, mounted suitably upon frames provided with binding-posts for the several wire connections.

Referring descriptively to figure 5, I is a local wire connecting the frame C of key A to the spring H of key B.

J is the main-line wire connecting to the spring G′, while the ground-wire N leads from the spring G. The key A is connected by wire M to the plus end of battery E, while a tap-wire, O, connects the minus end of said battery to a wire, L, which connects the plus end of battery F with the key B. The minus end of battery F connects by wire K to the point d of key B.

When the keys A B are connected, as shown in figure 5, with contact points c c' in connection with line I, the manipulation of



THE NICHOLSON QUADRUPLEX.

reverse the direction of the main-line current, and consequently its polarity in a certain direction; and this form of key cannot only be used in the manner specified in the first part of this preamble, but when slightly modified can also be used in other combinations, which I have shown in another application filed September 26, 1885, which is a division hereof.

In the accompanying drawings, figure 1 is a perspective view of my improved left main battery-key. Figure 2 is a detailed view of the key. Figure 3 is a perspective view of the right main battery-key. Figure 4 is a detailed view of the key. Figure 5 is a diagram illustrating the even batteries keys, and connections. Figure 6 is a diagram of a system in which the batteries are so connected to the keys that only one polarized and one non-polarized relay need be used at a station.

A and B are the manipulating keys for the currents from main batteries E and F. These keys are caused to control the currents by means of local batteries and keys acting upon the armatures to attract them with springs a b to resist. The key A is provided with insulated springs G G′, whose ends play between the double-hooked end of the key and two contact-points, c c', in the frame the keys will play the currents as follows: In order to at all times keep the main-line circuit intact when the keys A B are both open, the wires are connected to complete the main circuit from line to ground as follows: From line J, through spring G′, key A, wire M, battery E, loop or tap O, wire L, key B, spring H, and wire I, to point c', spring G, and thence to ground at N.

When the left key, A, is closed in the act of sending a signal to the distant station, the connection from line to ground is as follows: from line J, through spring G′, point c, frame C, line I, spring H, key B, wire L O, battery E, wire M, key A, spring G, and thence to ground through wire N. It will be observed here that the polarity of the battery to the line is reversed from that presented when the key A was open, and in this reversal of polarity lies the power of actuating the suitably-polarized relay at the distant station. When the key A is closed, the spring G′ leaves the hook of the key and engages with the point c, and the spring G leaves the point c' and engages with the hook of key A.

When the keys A and B are both closed in the act of sending two signals to the distant station, as in sending one of the compound signals of the Nicholson alphabet, the currents from both

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batteries E and F are brought (as they necessarily must be) into use as follows: The spring H leaves the hook B and engages with the point d in frame D. The circuit is then complete from line J, spring G′ point c in frame C, wire I, spring H, point d, wire K, battery F, battery E, wire M, hook-key A, spring G, and thence to ground through wire N. It will be seen that the polarity in this instance is the same to line that it is when the double key A alone is closed, and consequently the polarized relay at the distant station will be actuated, as also a relay of increased tension by reason of increased battery strength—viz., both batteries.

When the key B is closed alone in the act of sending a signal, the currents play as follows: from line J, spring G′, key A, battery E, through wire M, battery F, wire K, point d, spring H, wire I, point c', spring G, and thence to ground through wire N. Thus the right key employs both batteries to actuate the non-polarized relay. In the above arrangement I employ equal batteries, with one of them at all times in circuit, and employ but two relays at the distant station to receive the signals—viz., a polarized relay of plus polarity, capable of being operated by the minus current from a single battery, and a non-polarized relay of increased tension, capable of being operated only by the combined tension of both batteries.

Figure 6 clearly shows such a system adapted for simultaneously sending and receiving messages at both stations I. and II., the relays at each station being ordinary so-called "differential relays," each having one coil in the main-line circuit, and an opposing coil in an artificial line circuit, all as will be readily understood from said figure by persons skilled in the art. This apparatus is used for the transmission of messages by the Nicholson alphabet, and the finger-keys (not shown) in the local circuits of the line-current manipulating keys A and B are placed close together, after the fashion illustrated in my aforesaid patent.

The messages may be received by registers; but when they are received by sound the two sounders at each station are likewise placed near each other, and should sufficiently differ in tone or pitch to be clearly distinguishable by the receiving operator.

I claim—

1. The combination at one station of two independently-operated keys connected in the same circuit, one serving to control the polarity of the line-current, and the other, whenever operated, to control the tension of the line-current, without in any instance changing its polarity, substantially as specified.

2. The combination, substantially as specified, with the main line at one station, of a relay controlled by change of polarity and a relay controlled by change of tension, arranged to simultaneously receive two signals, and at another station two independently-operated keys connected in the same circuit, one serving to control the polarity of the line-current, and the other, whenever operated, to control the tension of the line-current, without in any instance changing its polarity.

3. In telegraphic transmitting devices, the combination of keys A, G, G′, and B H, secured to play, respectively, between points $c\ c'$ and $d\ d'$, with ground-connection N, line-connection J, local connections I K L O M, and even batteries E F, the whole to operate substantially as and for the purpose specified.

4. In telegraph transmitting devices, the key A, provided with insulated contact-springs G G′, situated to play between two contact-points, $c\ c'$, for the purpose substantially as specified.

5. The combination at one station, substantially as specified, of two separate main batteries, or two sections of a main battery, and two independently-operated keys connected in the same circuit—one serving to control the polarity of the line-current and the other to control the tension of the line-current—by alternately opening and closing one of the batteries, without in any instance changing the polarity of said current.

6. The combination, with a telegraphic circuit and battery, of two keys at one station, acting independently—one to reverse the polarity and the other to increase or decrease the strength of current—and two receiving instruments at the other station, operated independently, one by the change of polarity, and the other by the change in the strength of the current.

7. In combination with a telegraphic circuit, a battery, a portion of which is permanently in the line-circuit, and two independent keys or transmitters, the first key so constructed as to reverse the polarity of whatever current is passing from the battery to line without reference to the position of the second, and the second key so arranged as to increase or decrease the strength of the current in action at pleasure, without reference to the position of the first.

In testimony of which invention I hereunto set my hand.

HENRY C. NICHOLSON.

Witnesses:

JOHN E. JONES,
J. L. WARTMANN.

CAVEAT OF ANTONIO MEUCCI.

Filed December 28, 1871; Renewed December 9, 1872; Renewed December 15, 1873.

The following is a description of the invention sufficiently in detail for the purposes of this caveat:

I employ the well-known conducting effect of continuous metallic conductors as a medium for sound and increase the effect by electrically insulating both the conductor and the parties who are communicating. It forms a speaking telegraph without the necessity for any hollow tube. I claim that a portion or the whole of the effect may be also realized by a corresponding arrangement with a metallic tube.

I believe that some metals will serve better than others, but propose to try all kinds of metals.

The system on which I propose to operate and calculated consists in isolating two persons separated at considerable distances from each other by placing them upon glass insulators, employing glass, for example, at the feet of the chair or bench on which each sits, and putting them in communication by means of a telegraph wire. I believe it preferable to have the wire of a larger area than that ordinarily employed in the electric telegraph, but will experiment on this. Each of these persons holds to his mouth an instrument analogous to a speaking trumpet, in which the word may be easily pronounced and the sound concentrated upon the wire. Another instrument is also applied to the ears in order to receive the voice of the opposite party.

All these, to wit, the mouth utensil and the ear instrument, communicate to the wire at a short distance from the persons. The ear utensils being of a convex form, like a clock glass, enclose the whole exterior part of the ear, and make it easy and comfortable for the operator. The object is to bring distinctly to the hearing the words of the person at the opposite end of the telegraph.

To call attention, the party at the other end of the line may be warned by an electric telegraph signal or a series of them. The apparatus for this purpose and the skill in operating it need be much less than for the ordinary telegraphing.

When my sound telegraph is in operation, the parties should remain alone in their respective rooms, and every practicable precaution should be taken to have the surroundings perfectly quiet.

The closed mouth utensil or trumpet and the enclosing the persons also in a room alone both tend to prevent undue publicity to the communication. I think it will be easy by these means to prevent the communication being understood by any but the proper persons.

It may be found practicable to work with the person sending the messages insulated and with the person receiving it in free electrical communication with the ground. Or these conditions may possibly be reversed and still operate with some success. Both the conductors or utensils for mouth and ears should be—in fact, I may say, must be— metallic, and be so conditioned as to be good conductors of electricity.

I claim as my invention and desire to have considered as such for all the purposes of this caveat—

The new invention herein set forth in all its details, combinations and sub-combinations.

And more specifically, I claim—

First. A continuous sound-conductor electrically insulated.

Second. The same adapted for telegraphing by sound or for conversation between distant parties electrically insulated.

Third. The employment of a sound conductor which is also an electrical conductor, as a means of communication by sound between distant points.

Fourth. The same in combination with provisions for electrically insulating the sending and receiving parties.

Fifth. The mouth-piece or speaking-utensil in combination with an electrically insulating conductor.

Sixth. The ear-utensils or receiving-vessels adapted to apply upon the ears in combination with an electrically insulating sound-conductor.

Seventh. The entire system comprising the electrical and sound-conductor insulated and furnished with a mouth-piece and ear-pieces at each end, adapted to serve as specified.

In testimony whereof, I have hereunto set my name in presence of two subscribing witnesses.

Witnesses: ANTONIO MEUCCI.

SHIRLEY MCANDREW.
FRED'K HARPER.

A COURSE OF ELECTRICAL LECTURES.

A new course of lectures at the Lowell Institute, Boston, was opened on December 7, by Thomas D. Lockwood, of the American Bell Telephone Co. The general subject is "The Electric Telegraph and Telephone," the first lecture being on "The Genesis of the Electric Telegraph. The lecturer considered himself fortunate in that he had an unhackneyed theme, yet he expressed himself as realizing that he labored under difficulties in meeting the requirements of clearness, conciseness and accuracy. Boston, he said, should take an especial interest in all things relating to the

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transmission of sound by electricity, for it was here that Franklin and Morse were born, and here that Bell invented the telephone. He spoke of the writings of Jules Verne and the amusement with which we regard them, and asked what would have been thought of a writer with a knowledge of physical possibilities who should write stories foreshadowing the present triumphs of steam and electricity. He then traced rapidly the development of telegraphy, finding the crude beginnings in the sound and fire signals used as warnings and as signs 2000 years ago, and later in a more developed form in the semaphore system devised by Chappé, a Frenchman, and in use before the French revolution. A model of the semaphore was shown, and the method of signaling by means of its pivoted arms was explained. With this device, which was in common use in Europe soon after its introduction, despatches were sent over 100 miles. Lord George Murray, in England, planned a signaling device, of which a model was shown, arranged to display certain combinations of six letters, so that an alphabet was formed. This was used on eminences, that it might be seen at a distance, but cloud and mist often made its operation defective, as when London was thrown into confusion by a message saying "Wellington defeated"—and it was only some hours afterward that the remainder of the story came relieving the overwrought feelings of the people—"the French at Salamanca." Sometime after it had been superseded by electricity the semaphore was revived as a system of signaling, but it is now numbered among the things that were. The lecturer found the first real foreshadowings of the telegraph in the old fanciful story of the magnetic needles, to the effect that two needles magnetized from the same magnet, though worlds apart would yet move alike, one would follow the motion of the other. From this flight of the imagination Flaminius Stradar, an Italian Jesuit, in 1607, gave directions for making preparations for thus sending messages.

The idea that electricity might be used to carry signals was apprehended by many thinking minds, the speaker said, before the actual invention of the telegraph. He then discussed the different theories of electrical action, resting on that of certain kinds of molecular action as the one with the best foundation in fact. He spoke of the two theories that it is an imponderable fluid, theories, he said, not sustained by modern ideas. The modern theory, that a kind of polarizing force is exerted through matter by electrical action, he illustrated by a row of toy blocks, one being struck, the motion was transmitted, and the row fell. The discoveries leading directly to the telegraph next received attention, that of conduction and insulation, by Stephen Gray of the Charter House, London, in 1729, being considered the earliest and most important. Gray's experiments were detailed, and the meed of praise was bestowed upon his work which the lecturer considered his due. The varying conductivity of different substances was touched upon, and the speed of electrical transmission was strikingly illustrated. The experiments of Wheatstone and others to obtain the velocity of electricity were described, and the lecturer then told of 15 attempts to utilize frictional electricity for transmission before a more tractable kind of electricity was discovered. The different batteries devised after the invention of the voltaic pile were then briefly described, and the lecturer closed, announcing that owing to the close relation between electricity and magnetism he would give a few minutes before his next lecture to the consideration of the latter subject.

"The Principles of Electric and Electro-Magnetic Telegraphy" was the topic of the second lecture in Mr. Lockwood's Lowell Institute course, delivered December 10th. The speaker prefaced his lecture with the promised remarks on magnetism and magnets. He explained the properties of magnets, directive power, polarity and inductive power, and then proceeded to his lecture, saying that electro-magnetism as a union of the two forces, electricity and magnetism, was discovered by Oersted, a Danish scientist, his observation showing the power of the electric current to deflect the magnetic needle. This gave a great impulse to electric telegraphy and several needle telegraphs were devised. The next step in advance was the discovery in 1824 of the electro-magnet and its wonderful improvement by our own countryman, Professor Joseph Henry. After many preliminary steps by various scientists, Sturgeon, an Englishman, in 1824, first constructed a true electro-magnet with movable armature. This instrument was shown. The operation of the electro-magnet was then explained by the lecturer. One gentleman in England had said, after Sturgeon's experiments, that the electro-magnet could never become an adjunct in telegraphy. The lecturer then showed how Professor Henry had made Sturgeon's invention practical. The five fundamental steps toward the telegraph were thus summarized: The discovery of electric conduction and insulation by Stephen Gray, an Englishman; dynamic electricity and the voltaic battery by Galvani and Volta, Italians; the discovery of the relationship between electricity and magnetism by Oersted, a Dane; the invention of the electro-magnet by Sturgeon, an Englishman; its wonderful improvement by Henry, an American; and the use of the earth as a return circuit by Steinheil, a German. The fifth step included in the above summary was described, and great credit given to Steinheil for his unselfish position towards the Morse telegraph, and for his great discovery—the use of the earth as a return circuit. The lecturer spoke of the requisites of a telegraph system, and said that the principal kinds of telegraph instruments depend upon the discoveries of Oersted and Sturgeon, a third class depending upon chemical action. The needle telegraph of Cook and Wheatstone was then explained and illustrated by diagrams of two original Cook and Wheatstone instruments. The first telegraph of this system, according to Mr. Lockwood, was used on the Great Western Railway in 1838. The needle system is in use on most of the cable lines of the world. It was noted as singular that the Morse, originally a recording instrument, has become in practice a non-recorder, while the Cook and Wheatstone, a non-recording instrument, has become in cable use a recording machine by means of the siphon recorder. The Morse machine, the simplest and most practical of telegraph instruments, was then considered, and the lecturer briefly sketched the career of Mr. Morse. Professor Morse, he said, was justly entitled to date his discovery back to 1832. Morse's original machine is kept in the Western Union receiving room in New York city. The lecture was closed with a lucid explanation of various practical technicalities.

In his fifth lecture which was devoted to "The Telephone," Mr. Lockwood said that the meaning of the word "telephone" is "sound at a distance." The earliest published reference to the transmission of speech to a distance is found in a paper written by Robert Hooke in 1667. He stated "that he had propagated sound for a considerable distance over a distended wire." This was the transmission by the mechanical vibration of the wire of the sound itself, and illustrated the same principle as the common string telephones "or lover's telegraph" which have lately been hawked in the streets

In 1819 Wheatstone employed the same principle to convey musical sounds from one room to another. The possibility of the electrical transmission of speech was for the first time publicly admitted by a certain officer of the French army—Bourseul by name—in 1854. This gentleman described a sensitive plate which should rapidly, under the influence of the spoken word, make and break the circuit of a battery, and thus affect another similar plate at a distance. It is not known that Bourseul ever attempted to construct such an apparatus.

His mantle was, however, taken up in 1860 by Philipp Reis who, from that year until 1863, experimented in the same line and constructed a transmitter on the same principle, utilizing a receiving instrument based upon the discovery of Chas. Crafton Page of Salem that a magnetic bar would emit sounds when it was rapidly magnetized and demagnetized. It remained a pretty philosophical toy for years, and only three days before the issuance of Prof. Bell's patent, Dr. P. H. Van der Weyde, of New York, admitted this. It failed to transmit the compound sound vibrations of the human voice because it failed to maintain control of the line; it regularly broke the circuit and during the break had no means of imprinting the character of its vibrations on the line. Alexander Graham Bell took up the art in 1874 and taught the world how to talk over an electric wire; his exhibition of the speaking telephone at the Centennial exhibition before Sir William Thomson and Professor Joseph Henry, the greatest of American electricians, astounded the world.

The discovery of Bell is lucidly stated in the words of his own patent, *i. e.* "The transmission of vocal sounds telegraphically by causing electrical changes similar in form to the vibrations of the air accompanying the said vocal, or other sounds," and his invention consisted in devising an instrument which effect this result, and embody this discovery in a working instrument.

The lecturer here gave a brief exposition of sound, and of its principles utilized in the telephone, observing in conclusion that to transmit and reproduce human speech the quality of tone must be transmitted.

No less than six transformations of energy take place in the telephone between the transmission and reproduction of speech at a distance; the sonorous vibration of the original voice is first converted into mechanical motion by the vibrating of the transmitting diaphragm; this operates upon a magnet producing a variation of magnetism; this in turn is transformed into electrical energy which traversing the line is reconverted into fresh magnetic variations at the receiving end; these again producing mechanical motion at the receiving diaphragm which finally develops sound vibration, once more giving forth a copy of the original tones and words transmitted.

The ideal telephone is one in which both transmitter and receiver are identical in character; the telephone of Bell is adapted for use both as a transmitter and receiver.

It is not, however, a powerful transmitter, and in practice it has been found convenient to produce a steady electric current by a voltaic battery and to produce the necessary variations upon the line by employing a diaphragm vibrating with the sound waves of the voice to vary the resistance of the circuit, and thus to vary the strength of current flowing in the said circuit, the current being by a well-known electrical law inversely proportional to the resistance. Such instruments are known as transmitters.

The final lecture of the course upon the subject of transmitters was delivered on December 24.

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THE USE OF CABLES IN CITIES.

The following paper by C. N. Fay, of Chicago, read before the telephone convention at Providence in September, embraces matter of permanent interest in connection with wire distribution:

Gentlemen:—Two years ago, and again last year, I had the honor to lay before you a few observations on the use of cables in cities. That use has now become very general, and the conclusions drawn in my first paper are now matters of common experience. Most of us have been driven by our necessities to use air cables, in some cases over distances of two and three miles, and some of us are being driven by our legislatures and city councils to use underground cables. So far as I know, no cable overhead or underground, when properly made and connected up, has failed to work over a reasonable distance and for a reasonable length of time, and most of the cables which have been put in use are working still. The first broad fact which strikes us is that we have no serious trouble with property owners over whose premises we pass. Once in a while we strike a case where all ordinary arguments fail, and we must move; but as a rule we are safe in dealing with them. On the other hand, we are constantly attacked by our legislators, both state and municipal, who, as a rule, have no individual interest to protect from our occupancy. If these last were governed by common sense and the interest of their constituents, they would probably assent to the following propositions: That a telephone exchange is a direct benefit to all residents of a city or town; that no unnecessary restrictions should cramp its development or enhance its cost to the user; that the public streets were dedicated to public use by the abutting property owners in order to secure forever free access to their property, whether of men, vehicles, water pipes, light, air, telephones, or any other thing desirable to their use and comfort; that, therefore, they have a right to such access so long as the same does not beyond reason injure their neighbors. Given these premises, and broadly stating the fact that there is a strong popular feeling that all wires should be placed underground, let us consider first whether there are no circumstances in which public welfare, and with it public opinion, should demand the construction or retention of poles and wires, and afterwards where public welfare and public opinion should require us to place cables when used.

The objections brought against poles and wires are three in number: First and greatest, that they are really an eyesore; second, that they hinder the access of firemen to the fronts of tall buildings; third, that they block the streets. A fourth objection is often made in villages, that they interfere with shade trees.

The first objection, like the fourth, is valid upon handsomely improved streets, but upon streets which are, as the majority of streets are, totally destitute of any attempt at beauty, whose pavements are bad, whose sidewalks are uneven, whose buildings are mean and their occupancy wretched, it is most emphatically not valid. The second objection is valid where there are many tall buildings, but it is worthless where the buildings do not exceed two or three stories in height. The third objection is invalid upon all streets where there are street lamps, hitching posts, shade trees, awning posts or curbstones. For all these things are commonly set along the curb line, in line with the telephone poles, and the blocking of the streets is neither increased nor decreased by the erection of the latter.

The great and ruling objection to laying wires underground is the inevitable frequent tearing up of the pavements. There is no merchant who would not prefer a quiet, orderly telephone pole in front of his door to an upheaval of the roadbed every few weeks. But every telephone requires its own direct wire direct to the central station. In going underground, therefore, we must, in order to provide for new subscribers, either anticipate them by laying wires to each building, or tear up the streets to reach them as often as they come in. "But," our honest alderman will say, "you know that on the average one office in ten will require a telephone. Divide the number of offices in any block by ten and you have about the number of wires which will be required for that block. Lay a cable containing that number of wires from the exchange to the corner of that block, and then you have only to extend each wire a short distance by itself to reach its proper telephone, and the tearing up of the streets will be reduced to a minimum." Why tear them up at all? Why not locate the end of the cable in the centre of a block, and then extend each conductor by a short air line to each telephone therein? We know by experience we shall have no trouble from the property owners in doing this, and we shall cross no streets, so we shall have no trouble with the city authorities. Nay, let us go a step further. Why is it necessary in all cases to lay the cable from the exchange to this distributing point underground? There are many streets already so crowded below the pavement with gas, water and steam pipes, catch-basins, reservoirs, sewers and cable railroads, and above the pavement with surface railroads and traffic, that it is impossible to survey a satisfactory route for electric cables, or to protect them when laid from injury by heat, gas and excavations for these various installations.

Suppose, on the other hand, we arrange with the owners of intervening buildings to run the cable from the exchange to the distributing point over the roofs of their buildings. Our experience shows that we can do this without difficulty. What objection can be urged by a fair-minded city councilman against our crossing the streets from building to building? The only thing that can be said is that they are an eyesore. This is true, but to how slight an extent. So little do the passers observe these things that in the last three years my company has removed from the roofs of Chicago, in its most crowded portions, over 2,400 telephone wires, some of them on racks 36 feet high, carrying 200 or more, and replaced them by some 30 cables carried over the roofs on short iron posts, without attracting a word of newspaper comment

What is the relative value and convenience of a cable over roofs compared with one underground? There is no doubt that under some circumstances it is desirable to place these cables in the roadway, particularly long cables running between central offices for use as trunk lines. Or in cases where a number of cables cross buildings in the neighborhood of an exchange. Cables underground could not be burned in two by fires, or cut by malicious persons, or suddenly ordered moved by a cranky landlord. Yet despite all these annoyances, from which we have often suffered, I can but think the roofs the proper place for them. If I am correct in what I have said, an honest, clear-headed common council, acting strictly in the interests of the public, will not pass ironclad underground ordinances, which cannot be enforced without burying a large portion of the business and the public convenience along with the wires.

ELECTRIC MOTORS IN NEW YORK CITY.

The Sprague motor having been officially recognized by the Edison Electric Light Company as the only practical motor, for general satisfactory use on their circuits, a large number of them have been introduced in connection with their central stations.

The New York company having had its present capacity nearly taken up in supplying lights, they have been able for the present to introduce only a few. These are applied to a variety of purposes.

Simonds M'f'g Co., of 50 Cliff street, run a spur gear freight elevator.

J. L. Morgan & Co., 47 Fulton street, are running a steel screw elevator.

These motors have been worked up to 60 per cent. above their rated capacity.

The Thompson & Bedford company are using a motor to run their oil testing machine.

Ventilating fans of the Wing pattern are being run at the Simonds M'f'g Co.; Moquin's restaurant; the N. Y. Stock Exchange; Leggett and Bros.; and recently at the temporary B. and O. operating rooms.

The Sprague automatic motor has been adopted by the Gold and Stock Telegraph Company for driving the transmitters in the cable office building.

Printing presses and polishing machinery in smaller establishments are being run, and one of the metropolitan morning journals has been considering the question of running its presses entirely by motors, and would require about 140 h. p.

These motors are some of them of variable speed, others perfectly automatic, running at the same speeds for all loads up to maximum.

The Western Union company after an exhaustive trial have signed a contract for the ventilation of their main operating room.

At present there will be four Wing fans and four Sprague motors put in. The fans will have a maximum hourly capacity of over 2,000,000 feet. The motors will be controlled by separate regulators, and can be run at speeds varying 100 per cent. The current will be supplied by an Edison dynamo in the basement. The plant will be running early in January.

The Sprague company are very privately pushing some elevated railroad experiments as fast as four manufacturing firms, the best in their line, can get out the work. These motors are being built for a 600 volt. constant potential circuits, run at all speeds up to 1,300, with single sets of brushes, and fixed nonsparking points independent of the load, speed, and direction of rotation. Another feature will be the entire absence of all braking attachments, the momentum of the car and the motor regulators affording perfect control. These motors will be running in February.

The Sprague company are contemplating the erection of stations for the distribution of power alone over large districts under 300 or 400 volts. constant potential circuits.

At present, unlike all other electric companies, this company is a private corporation. Its work is being done by individual capital, and it is free from all alliances which limit the use of its motors.

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TELEGRAPH AND TELEPHONE WIRES IN NEW YORK AND BROOKLYN.

The following statistics of wire mileage are substantially correct being compiled from official figures. The estimates are mainly based upon accurate information.

	New York.		Brooklyn.
Western Union Telegraph Co. (actual)	4,986	(estimated)	246
Gold and Stock Telegraph Co. "	415	"	15
Metropolitan Telephone and Telegraph Co. (estimated)	7,900	"	420
New York and New Jersey Telephone Co	.....	"	3,150
United Lines Telegraph Co. (estimated)	250		.....
United Lines District Telegraph (estimated)	175		.....
Baltimore and Ohio Telegraph Co. "	500	"	12[illegible]
Baltimore and Ohio District Telegraph (estimated)	240		.....
American District Telegraph Co. (actual)	555	"	200
Other District Telegraphs (estimated)	[illegible]00	"	290
Commercial Telegram Co. "	100		....
Fire Department "	1,000	"	240
Police Department "	60	"	100
Totals	16,681		4,781

It will be observed that this list does not include electric light wires, and is therefore an underestimate so far as the total wire mileage of the two cities is concerned.

THE LAW REGARDING TELEPHONE SUBSCRIBERS.

In deciding the suit brought by the Baltimore and Ohio Telegraph Co., against the Bell Telephone Co. of Philadelphia, Judge Arnold delivered an opinion at Philadelphia, December 7, settling for the first time in Pennsylvania several important principles of the law relating to modern electrical invention. The telephone company refused the application of the telegraph company for a telephone in the main office of the latter company at Third and Chestnut streets, on the ground that by the terms of its contract with the American Bell Telephone Co. it was prohibited from furnishing telephones to be used in connection with the transmission of telegrams to any company other than the Western Union Telegraph Co. Suit was brought in Common Pleas Court No. 4, and a mandamus was prayed for requiring the telephone company to furnish the desired facilities to the complainant. In passing upon the case Judge Arnold says: "It is admitted that the use of the telephone is a public necessity, which no other human agency can supply. Consequently the telephone business is a public business. To show that the refusal of the telephone company to furnish the relator a telephone for the purpose of receiving or delivering telegraphic messages is an unjust and unreasonable discrimination; it is averred that the respondent has placed an instrument in the office of the Western Union Telegraph Co., and permits that company and its customers to use the telephone for that purpose. The respondent alleges that it is the licensee of the American Bell Telephone Co., and subject in its dealings with the people of Philadelphia to the terms of the contract under which its license was given." The judge quotes at length from an agreement between the American Bell Telephone Co. and the Western Union Telegraph Co., to show that the latter is not a patentee, which was granted a license for a restricted use of its patents to the telephone company, reserving a certain exclusive use to itself, but that it is a licensee paying to its licensor an additional compensation or royalty upon every message received or delivered by it. "The Western Union Telegraph Co.," he continues, "has given up its claims to all such patents, and the Bell Telephone company has put them into public use, thereby subjecting them to the rule that when the use of a patented device is thrown open to the public all are invited to use it on the same terms. The rules which govern common carriers apply to it, and those rules prohibit any discrimination. It has been decided that a contract giving to one express company an exclusive right of transportation in the passenger trains of a railroad company is illegal and void." Quoting from the 33d section of the Corporation Act of 1874, the judge continues: "The respondent was chartered under that act, which gives it a legal existence and prescribed its duty at the same time. It cannot transact business in this state but for that act, and operating under that act it must deal equally with all, with impartiality and good faith, and without discriminating in favor of or against any one." After fortifying these conclusions with a number of decisions the judge's opinion resumes: "A public servant cannot avoid the performance of any part of the duty it owes to the entire public by a contract even with the patentee of an invention. Doubtless a condition limiting the use which should be made of the telephone, affecting all classes of citizens and discriminating between none, might be valid, but, having the right to use the telephone, the relator may use it for the same purposes that other subscribers use it. In a case precisely similar to this, between the same parties, just decided in the Circuit Court of the United States for the Eastern District of Missouri, Judge Brewer held that the telephone company having put its patents into public use, the property is put within the power of the court for enforcing the obligations of a common carrier. In the case before us the American Bell Telephone Co. is not a party, and we do not think it indispensable that it should be. We are not called upon to expound or enforce the contract between that company and the Philadelphia company. What we are called upon to do is to declare that the illegal portions of that contract cannot be enforced in this state; that those portions are void and against public policy as declared both by the common law and by statute; and that the respondent cannot shield itself from the performance of its duty to serve the public impartially and without discrimination by a contract with a party not within the state. We deal with parties carrying on a public business within our borders under the protection of our laws, to compel them to comply with those laws. They cannot obtain immunity from their obligation to treat all alike by pleading a license from parties beyond our grasp. The owner of a patent may put it in public use or withold it, as he chooses, but if he does put it in public use, then, as was well said by Chief Justice McIlvaine, of Ohio: 'The manner of its use may be controlled and regulated by state laws when the public welfare requires it.' The patent gives him a monopoly by protecting him from the competition of other persons in the business secured by the patent, but it does not permit him to make discriminations between persons who are willing to pay the same rates which other persons are charged for the same use. We say nothing now on the subject of charges by the respondent for the use of the telephones, except this: Whether it shall be an annual rental or a tariff of charges upon messages, it must be the same for all. A writ of peremptory mandamus is awarded.

THE STATEN ISLAND BANQUET.

The proposed arrangement by which the Baltimore and Ohio Railroad Co., is to secure terminal facilities in New York harbor has awakened great interest in financial circles, as well as among the residents of Staten Island and New Jersey. The consummation of the preliminary negotiations which assure the prosecution of the work was celebrated by a grand reception to President Robert Garrett, given on Wednesday, December 16th. The occasion afforded an opportunity for reviewing the history of this venerable corporation, and the remarks of John H. B. Latrobe, show that in engaging in its recent telegraph enterprises the Baltimore and Ohio is but reviving its early friendship for an art which was then but a tender, budding plant. The following is an extract from Mr. Latrobe's remarks:

"In the month of May, 1828, the late John V. L. MacMahon and myself were employed by the Baltimore and Ohio Railroad Co., to obtain rights of way on the Potomac river in anticipation of a contest with the Chesapeake and Ohio Canal Co., for the route in the narrow passes where there was not room for both works between the river and the mountains; and my first experience was to demonstrate to the owner of the Point of Rocks the value of his property for the proposed scheme. Railroads were myths in those days in America, and if I drew on my imagination in my description I was in no danger of an adverse criticism. This was in the first decade of the road, when Mr. Philip E. Thomas, was president, a shrewd and far-seeing member of the Society of Friends, of an abiding faith in the work and of wondrous perseverance. Mr. Thomas's decade was distinguished by Peter Cooper's demonstration, with a sort of Tom Thumb locomotive, of the practicability of using steam on the abrupt curves then thought to be inseparable from railroads in America. It is very true that his locomotive failed, when his blowing apparatus gave out momentarily, and most inopportunely, in the crisis of a contest with a horse and car on a parallel track, and Mr. Cooper lost the race. But the victory was in the demonstration that the race afforded, the results of which he lived long enough to see, when the Tom Thumb of 1832 had a progeny of giants which was fast obtaining the mastery of the world. It was in Mr. Thomas's time, too, that the eight-wheeled car became the passenger car of America; and during the same decade the contest with the canal company for the right of way brought before the courts of Maryland, Taney and Webster and Reverdy Johnson on the one side, and Wirt and Walter Jones on the other—Taney in the Court of Chancery, and Webster, who took his place when the former was appointed Attorney-General, in the Court of Appeals. Webster, massive, grave, and sententious; Wirt, one of the handsomest men of the day, graceful and refined; Walter Jones, with no personal advantages, the quickest, brightest, and probably the acutest lawyer of the four, and Johnson, the youngest on his way to the eminence that he afterward reached. It was something to see, in the close connection with Mr. Webster that the trial brought about, the inner action of the grand mental machinery which elaborated the material that it was my function to furnish from my experience in the courts below into the great argument that was finally delivered.

Mr. Thomas's decade closed with the road at Harper's Ferry, to which it was permitted to go in Maryland by a compromise which ensued on the defeat of the company in the Court of Appeals. Then followed the second decade, under the presidency of Mr. Louis McLane, statesman and orator, secretary of state, secretary of the treasury, minister to England. Taking up the road at Harper's Ferry, with no alternative but to pass through Virginia to Cumberland, he made an otherwise unavailable subscription of $3,000,000 of the city of Baltimore the basis, during a suspension of specie payments, of orders redeemable in it, and carried the road to Cumberland. But, while Mr. Thomas's decade was distinguished in the way that has been described, Mr. McLane's had its earmarks too. In 1843, Congress had appropriated $30,000 to enable Morse to test, in actual use, his telegraph, whose demonstrations had so far been limited to the transmission of messages from one committee room in the Capitol to another; and as the Washington branch of the Baltimore and Ohio railroad afforded the most convenient opportunity he applied for permission to establish a wire upon it. A question as to the company's power in the premises having arisen, the president suggested that I should find out something of the matter, of which both of us were ignorant. A single interview with the inventor imbued me with his enthusiasm; and my report to the president was, that numerous and exalted as had been the positions he had held, his name would be forgotten, while that of Morse would be echoed throughout the ages, or something to this effect. Mr. McLane now became enthusiastic himself, and when the resolution granting the permission came before the directors the only dissenting voice was that of a member who said that he could not conscientiously be a party to what would help Mr. Morse, who seemed to be an honest man, to ruin himself by prosecuting so impracticable a scheme. Thus it was that the Baltimore and Ohio Railroad Co., became interested in telegraphy in the infancy of the art, and it now, after many years, finds itself again engaged in promoting and cheapening its usefulness.

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THE EDISON TELEPHONE PATENT UPHELD IN CANADA.

The taking of evidence before the Deputy Minister of Agriculture, on the application of the Telephone Manufacturing Co. of Toronto, has been concluded and a decision rendered. The application was to have the Edison telephone patent, now held by the Bell Telephone Co., declared void because of the importation, non-manufacture and refusal to sell by the Bell company. The Bell patent proper was annulled last year, but the Edison patent still holds good, and as the Bell company has brought an action against the Telephone Manufacturing Co. for an infringement of the last named patent, this application was made to set it aside.

In giving judgment upholding the validity of the Edison telephone patent and dismissing the application to have it annulled, Dr. Tache, deputy minister of agriculture for Canada, held that the charges of importation, non-manufacture, and refusal to sell had not been proved as regards patent Nos. 8,026 of 1877, 9,922 of 1879, and 9,923 of the same date, issued to Thomas Alva Edison, and now owned by the Bell Telephone company. He decided that the setting aside of Bell's patent last year for importation and refusal to sell did not affect the Edison patent, though both were owned by the same company. The voidance of one patent for telephones does not, in the deputy minister's opinion, entail voidance of another patent for telephones, because they stand as distinct combinations. Bell's patent was declared null and void by the minister of agriculture because there was ample proof of importation in the forbidden time having taken place, to the notable detriment of home labor, and because there was sufficient proof of refusal to sell which amounted to non-manufacture, while in Edison's case there was no such proof as applied to any one of the three Edison patents. These several patents acquired by the Bell company are all for the purpose of telephonic communication. They all make use of the same elements, but they are distinct combinations and have a right to stand as separate inventions. This is a fundamental principle in patents in all countries, there being everywhere a great many patents of combinations for an entirely new art or mechanism. It is further declared that a patentee is within the meaning of the law in regard of his obligation to manufacture, when he has kept himself ready either to furnish the patented article or to sell the right of using, though it may be that not one single specimen of the article has been produced, and he may have voided his patent by refusal to sell, although his patents were in general use. The Bell company, therefore, continue the telephone monopoly in Canada by means of Edison's patents.

WESTERN UNION'S REDUCED DIVIDEND.

According to report there was considerable difference of opinion at the meeting of Western Union directors this week with reference to the declaration of the January dividend. Some members favored the maintenance of a six per cent. per annum rate and the consequent declaration of a one and one-half per cent. dividend for the quarter. The Gould influence is however, represented as opposing such action, and finally influencing the declaration of a dividend at one and one-quarter per cent. The report submitted for the quarter is sufficiently discouraging, and in connection with the above facts gives emphasis to the reputed bearish attitude of Mr. Gould upon the stock of the company. Compared with the corresponding period of 1884 it shows the following results, it being understood that the returns of October and November are partial and those of December estimated.

	1885.	1884.	*Changes.*	
Quarter ending Dec. 31	$1,250,000	$1,500,000	Dec.	$250,000
Add surplus Oct. 1	4,230,958	4,159,190	Inc.	71,768
Total	$5,480,958	$5,659,190	Dec.	$178,232
Interest on bonds and sinking fund	143,768	144,000	Dec.	232
Balance	$5,337,190	$5,515,190	Dec.	$178,000
Dividend 1¼ per cent	1,000,000	*1,199,837	Dec.	199,837
Surplus	$4,337,190	$4,315,353	Inc.	$21,837

*Dividend of 1½ per cent.

In connection with the figures the statement is made that the estimates of net earnings for the past and present quarters have been materially reduced by the extraordinary expenses of cable repairs of both the Atlantic and Cuba cables, by large payments on account of litigated taxes, and for taxes in a number of the states which are payable in the autumnal quarters, exceeding by about $400,000 the ordinary expenditures.—*Bradstreets*, Dec. 12.

DECISION IN FAVOR OF THE BELL COMPANY.

In the United States Circuit Court at Pittsburg, December 10, in the case of the Bell Telephone Co. against the Western Pennsylvania Telephone Co., Judge McKenna decided that the defendant instrument was an infringement on the Bell patent, and granted a perpetual injunction, as asked for by the Bell Telephone company.

ELECTRIC LIGHT AND POWER.

Domestic.

The St. Louis Illuminating Co. is completing its large central lighting station on Gratiot, between Second and Third streets. The system of lighting will be the Heisler incandescent.

The Independence (Kas.) Electric Light and Power Co., capital stock $12,000, has been incorporated to furnish light to city and private parties, and power for mechanical and manufacturing purposes.

The Brazil Electric Light Co., of Brazil, Ind., has been founded, with a capital of $5,000.

The Cambridgeport (Mass.) factory of the Boston Woven Hose Co., is now lighted by 150 incandescent lamps furnished by the Consolidated Electric Light Co.

The City Electric Railway Co., of Chicago, has been incorporated. Capital stock, $3,000,000.

The New York and Brooklyn bridge has awarded a contract for the new 10-light dynamo, and other additions to the electric lighting plant, to the United States Electric Lighting Co. for $1,325.

Upon taking apart the machine which furnishes the power for the Skowhegan (Me.) electric lights, to ascertain the reason for its not working properly, the discovery was made of a considerable quantity of coarse gunpowder which had been placed in the journal of the dynamo.

The Anthracite Electric Light Co. at Pottsville, Pa., which has an exclusive charter, has been united with the gas company in that town, the consolidated interests now controlling both systems of lighting.

By the use of natural gas as fuel the electric light company at Pittsburg enjoys a privilege in obtaining cheap power which is likely to lead to a prosperous future.

The Independence (Kas.) Electrical Light and Power Co., capital stock $12,000, has been incorporated to furnish light to city and private parties and power for mechanical and manufacturing purposes.

The Van Depoele Electric Light Co., of Chicago, have contracts for an electric street railway in Detroit, also to supply the Minneapolis, Lyndale and Minnetonka railway with electric motors to operate over that portion of their line within the city limits.

Plans and specifications have been filed at the Treasury Department, Washington, by F. A. Cloudman, of Rondout, N. Y., for the illumination by night of the Atlantic Ocean, by means of specially devised lightships, bearing electric candles of enormous power, and connected with each other and with a submarine cable by suitably adjusted wires. The practicability of this is based on what are styled two undisputed possibilities—namely, that a lightship will lie at anchor in a heavy sea without protection, and that electrical communication may readily be maintained from such a ship with the two continents.

Foreign.

Edwin Goadby in a recent prize essay on commercial depression, places the amount lost in electric light ventures at about £8,000,000.

The Blackpool (Eng.) electric tramway is now in full working order, and cars are running daily in both directions throughout the entire length. The corporation, at whose cost the tramway was laid, have issued a statement of the cost of the construction of the line, which, with the crossing places and the double portion on South Beach, is two miles 1,000 yards. From this it appears that the total sum expended has been £11,012. The cost of the electrical portion will not be known until the publication of the company's accounts.

Numerous experiments have been tried relative to the use of the electric light for navigation in the Suez Canal, and as they have at length proved quite successful, it has been determined to permit, from the 1st of January, all vessels of war and postal steamers provided with the requisite electric lights to navigate by night in that portion of the canal comprised between Port Said and kilometer 54. This portion includes almost half of the sidings or passing places, so that after that day vessels with the electric light will be able to continue their passage at all times of the night.

MANUFACTURING AND TRADE NOTES.

Exhaustive tests of the efficiency of the Jarvis patent furnace supplied by the Jarvis Engineering Co. of Boston, show an economy in the use of screening mixture over egg coal of 31% and over Cumberland coal of 17½%. The company is about establishing a western agency at Chicago in charge of H. A. Glasier, vice-president.

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Notwithstanding the low price of ingot copper, the prices of the manufactured article have been so well maintained that the Calumet and Hecla company contemplate the establishment of factories at the mines, where the goods will be made up and placed on the market. If carried out this will be an immense enterprise, and probably lead to a decline in the prices of manufactured copper, which will be of some benefit to the consumer.

The Westinghouse engine seems to be appreciated abroad as well as at home. Within a month engines have been ordered from Buenos Ayres, Haut Saone, France; Havana, Cuba; Rotterdam and Leyden, Holland, the latter being for the Government Physical Laboratory.

It is said that Mr. Westinghouse has made an offer to the stockholders of the Westinghouse Machine Company to advance $175,000 in $25,000 installments if the stockholders will relinquish half their stock. He proposes to have electric machinery manufactured at the works, and will give employment to more men.

The Western Electric Company, of Chicago, on the 12th of December filed four bills in equity in the United States Circuit Court against Wm. Pease, Marshall Brothers, Eugene Ingold and Ernest Axthelm, praying that they be restrained from manufacturing an electric elevator indicator, infringement of patent held by plaintiff.

The Jarvis Engineering Co. has completed its contract with the Narragansett Electric Light Co., Providence, R. I. The two six-foot steel boilers with the Jarvis patent setting are furnishing steam for six Armington and Sims engines of 300 indicated horse-power. The fuel used is a mixture of screenings and soft coal.

RAILWAY SERVICE.

A local branch of the American Train Despatchers' Association was organized at Jersey City on Sunday, November 15. Delegates were present from the Pennsylvania Railroad, New York City and Northern Railroad, Delaware, Lackawanna and Western Railroad, New York, Lake Erie and Western Railroad, New York, Ontario and Western Railroad, Long Island Railroad, New York, West Shore and Buffalo Railroad, and Lehigh Valley Railroad. The following officers were elected: M. W. Maguire, New York City and Northern Railroad, president; H. J. Quigg, Long Island Railroad, vice-president; W. C. Hartigan, New York, Ontario and Western Railroad, secretary and treasurer.

SUBTERRANEAN LINES.

The Wheaton Sub-Electric Conduit Co has been incorporated in New York city, with a capital of $1,500,000, for the purpose of laying wires underground. The corporators are John A. Belvin, Samuel Conover, Charles A. Post, John J. Kiernan, John A. Todd, Stephen T. Willet and Henry A Heiser.

THE TELEGRAPH.

The entire effects of the Postal Telegraph and Cable Company, in Baltimore, were sold at auction December 10th, and realized about $550. The sale included all the telegraph instruments, battery, ten miles of wire, and 300 messenger call boxes and a horse and buggy. Much of the property was bought by junk dealers.

The Arkansas Telegraph Company completed its new line between Little Rock and Hot Springs, Ark., and opened the same in connection with the Baltimore and Ohio Telegraph Company's system on December 16th. This is the line about which there has been so much conflict between the Arkansas Telegraph Company and the employés of the Western Union Telegraph Company and the St. Louis, Iron Mountain and Southern Railroad Company. The Supreme Court of Arkansas has affirmed the judgment of the lower court, giving the Arkansas company the right to build its line on the right of way of the railroad company.

Articles of incorporation of the International Railway Telegraph and Telephone Company, of New York, capital $1,000,000, have been filed at Albany. This company controls the Edison-Gilliland-Smith system of communicating between moving trains on the railways.

The case of the Southern Telegraph Company was up in the United States Circuit Court, before Judge Hughes, at Norfolk, Va., Nov. 10. The petition of Fowler and others was dismissed, and the decision rendered in the case of the Bankers and Merchants' *vs.* The Southern Telegraph Company, in New York recently, was ordered to be incorporated in the master's report to the court. Several lawyers were present from New York and other cities, representing bondholders. There is talk of a good many bonds being forgeries.

The Supreme Court of Louisiana at New Orleans, November 30th, affirmed the judgment of the lower court in the case of the Baltimore and Ohio Telegraph Company *vs.* Morgan's Louisiana and Texas Railroad Company and the Western Union Telegraph Company. The suit was originally brought to enable the Baltimore and Ohio Telegraph Company to build its line in the right of the way of the railroad company between New Orleans and Lafayette, Louisiana, 144 miles. The right was awarded, damages assessed and paid into the court, and the case appealed in the interest of the Western Union Telegraph Company, which claimed an exclusive right of way under a contract of the usual character. This decision establishes the right of the Baltimore and Ohio Telegraph Company. The line in question has been in operation since January 1st, 1885. The motion of the Western Union company to remove the case to the Federal court was denied.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICIAN AND ELECTRICAL ENGINEER *by* Pope & Edgecomb, *Solicitors of Patents for Electrical Inventions*, 11 *Wall Street*, *New York city*.

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From November 17th to December 15th, 1885 (inclusive).

Alarms and Signals:—*Combined Annunciator and Alarm*, F. E. Kinsman, 330,903, Nov. 24. *Apparatus for Detecting the Presence of Gas*, G. H. Eaton, 331,119. *Automatic Annunciator*, C. W. Price and A. Barrett, 331,257. *Signaling Apparatus*, J. P. Tirrell, 331,463, Dec. 1. *Indicator*, C. H. Pond, 331,650. *Register and Recorder for Fares*, E. A. Scales, 331,826, Dec. 8. *Automatic Circuit Breakers for Burglar Alarms*, J. B. Yeakle, 332,130. *Electric Mat*, H. H. Hoffman, 332,2'4, Dec. 15. *Signaling Device*, J. D. Fee, 332,336 *Magneto-Electric Indicator*, J. C. Boyle, 332,480. *Fire Alarm*, S. A. Chase. 332,638.

Clocks:—*Contact Maker for*, L. H. Spellier, 330,632, Nov. 17. *Synchronizer*. A. Ramel and W. W. Dean, 330,923, Nov. 24. *Primary Clock*, W. L. Stevens and E. J. Wescott, 330,938.

Commutators:—*Switch or Circuit Controller*, M. J. Wightman, 330,940, Nov. 24

Conductors, Insulators, Supports and Systems:—*Insulating Tube for Wires*, H. B. Cobb, 330,873, Nov. 24; *same*, S. B. Cobb, 330,874. *System of Temperature Regulation*, W.S. Johnson, 331,406, Dec. 1. *Tower*, B. F. Orton, 331,817 Dec. 8. *Underground Conduit*, E. A. Street and R. W. Fleming, 331,918, Dec. 8; same, J. A. Barrett, 332,318, Dec. 15. *Apparatus for Molding Sections of Conduit*, J. R. Burdick, 332,047, Dec. 8. *Insulator*, B. M. Deblieux, 332,061. *System of Pipes*, W. A. Hoeveler, 332,149. *Coupling for Lightning Rods*, A. J. Munson, 332,673, Dec. 15. *Lightning Rod Standard*. 332,383.

Dynamo Machines and Motors:—*Armature Core for Dynamo*, M. M. Slattery, 330,433, Nov. 17. *Dynamo*, O. F. Jonsson, 330,836; H. Muller, 341,726, Dec. 1; B. F. Orton, 331,815, 331,818; F. G. Waterhouse, 332,685, Dec. 15: B. F. Orton, 331,155, Nov. 24, *Armature for*, C. T. Jackson, 331,502, Dec. 1. *Regulator for*, W. M. Schlesinger, 331,552, Dec. 1; B. F. Orton, 331,814, 331,816, Dec. 8. *Motor*, W. S. Hill, 331,880. *Combined Engine and Dynamo*, J. H. Vail, 331,924. *Commutator for Dynamo*, C. D. Jenney, 332,399, Dec. 15. *Ventilating Device for Dynamo Commutator*. C. Parham, 332,427. *Motor or Dynamo*, W. Main, 332,668.

Electrolysis:—*Apparatus for Electro-Plating*, H. R. Boissier, 331,609, Dec. 1.

Ignition:—*Gas Lighter*, J. Geary, 331,630, Dec. 1. *Fire Arm*, J. K. G. Gavitt, 332,071, Dec. 8.

Lamps and Appurtenances:—*Lamp*, E. Weston, 330,450, Nov. 17; G. C. Pyle, 331,327, Dec. 1. *Incandescent Lamp*, C. Heisler, 330,586, Nov. 17. *Method for Carbonizing Filaments*, E.P. Thompson, 331,663, Dec. 1. *Clamping Device for Incandescent Lamps*, C. G. Perkins, 331,002, Nov. 23. *Method of Preparing Glass for Cementation*, C.F. Brush, 351,764, Dec. 8. *Arc Lamp*, T. L. Willson, 332,173. *Electric Light Attachment for Speculums*, C. Smith, 332,453, Dec. 15. *Rheostat*, E. Weston, 330,449, Nov. 17.

Miscellaneous:—*Medical Induction Coil*, J. C. Veltier, 330,531, Nov. 17. *Fire Escape*, H. F. Neumeyer, 331,081, Nov. 24. *Apparatus for Dental Operations*, C. A. Eisenhart, 331,121. *Means for Turning On and Shutting Off Gas*, L. R. S. White, 331,221. *Steno-Typograph*, A. Beyerlen, 331,275, Dec. 1. *Method of Straightening Needles, etc.*, G. M. Eames, 331,386. *Device for Operating Safe-Bolt Work*, E. W. Fowler, 331,390. *Contact Device for Suspended Electric Conductors*, C. J. Van Depoele, 331,585. *Platen Shifting Attachment for Type-Writers*, C. S. Southworth, 331,653. *Cut-Off for Engines*, R. A. Bailey, 331,674. *Frictional Electrical Generator*, P. Atkinson, 331,754, Dec. 8. *Making Magnets Self Keeping*, E. B. Silliman, 331,830. *Circuit Controller*, L. H. McCullough, 331,986. *Transmission of Power*, W. M. Schlesinger, 332,009. *Regulator for Dampers*, W. E. Facer, 332,066. *Perforating Machine*, J. E. Munson, 332,419, Dec. 15. *Automatic Circuit Breaker and Closer*, M. J. Myers, 332,420. *Therapeutical Belt*, C. N. West, 332,467. *Induction Coil*, J. A. Robison, 332,559.

Protectors:—*Safety Fuse*, G. Pfannkuche, 332,286, Dec. 15. *Telephone and Telegraph Protector*, C. C. Drake, 10,663 (Reissue), Nov. 24.

Railways and Appliances:—*Railway*, J F. McLaughlin, 330,605, Nov. 17. *Signal for Railroad Cars*, J. R. De Mier, 331,042, Nov. 24. *Railway Car*, J. A. Enos, 331,388, Dec. 1. *Railway Signal*, J. W. Henderson, 331,879, Dec. 8; W. M. Pease, 332,431, Dec. 15.

Storage Battery:—E. Jones, 331,407, 331,408, Dec. 1.

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HERE'S A STATE OF THINGS.

IT has been thoroughly understood in electrical and political circles, that the real motive of the underground agitation in this city which has continued with more or less violence for the past three or four years, has been the prospect of financial gain. The voice of the people has been manufactured for the occasion by the daily press. The movement thus begun has been carried on in spite of the protests of those who were well versed upon the subject, until state laws have been enacted for the very purpose of forming a monopoly, which should control the entire subterranean wire system of New York city.

Those who have supposed that such an undertaking could be successfully prosecuted without permitting any person to turn an honest penny, must be deplorably ignorant of human nature. The whole project has been jealously watched by hundreds who have hoped to profit by its development. Plans and systems patented and unpatented, tried and untried, practical and theoretical have been presented for examination and approval. So complicated did the situation become, that the task grew more formidable as investigation continually brought new facts to light. Despairing of success in discovering that perfect system which it was felt should be adopted for the city of New York, it is now asserted that in accordance with the law the commission appointed for that purpose, proceeded to devise such a plan as might meet the exacting requirements of the electrical and civil engineer.

Owing to one of those unfortunate oversights common to legislative action, no provision was made for funds to construct so expensive a work as this promised to be, and it is alleged that a syndicate was formed in the interest of those who were behind the scenes for the purpose of constructing the system after it had been devised. It may appear somewhat strange, but by a curious coincidence it is stated that the organization of a company to carry on this work fell into the hands of certain friends of the commissioners, or friends of their friends. There may be those who have hoped that an opportunity of this kind should have been offered either to enemies or strangers, but this code of ethics does not prevail to a great extent in New York political circles.

It was evident to those who were familiar with the various plans laid before the commission, that none of them covered all the essential features, and it is apparently for this reason that an attempt has been made to select some of the good points from the different systems presented. In its efforts to comply with the law the commission unfortunately neglected to invoke the assistance of the engineering experts associated with the daily newspapers and it is therefore impossible for them to arrive at a final determination which will satisfy the public—that is to say the editors of the journals in question. Without full knowledge of what has been determined upon, it is impossible to pass upon the merits of the proposed system, which has not been officially made public. Not even the wisdom of a Solomon would suffice to point out a course which would meet the approval of the press as well as the companies interested. A large proportion of the people who have devoted their time, money and energy to the invention of subterranean wire systems, and preparations for their introduction will be left out in the cold whatever may be the final outcome of this crusade against overhead wires. The commissioners having invited the presentation of plans, investigated the different systems which have been practically used in other cities, and having duly deliberated over the various arguments for or against them at the hands of such experts as they may have consulted appear to have complied with the letter and spirit of the law, in devising a system. Whether it will answer the purpose or not, may be determined by experience. This is most certainly a case in which it will be an utter impossibility to please everybody.

It is intimated that representatives of the Western Union

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Telegraph and American Bell Telephone companies will be interested in the future subterranean system. This is one of the unfortunate possibilities of the general scheme which has been proposed for doing away with overhead wires. Securing the control of joint-stock companies is usually a mere matter of dollars and cents, and if any provision has been made to guard against such a change of ownership it has not been brought to our notice. The past policy of the Western Union has not been of that subservient character which would allow it to submit mildly to the jurisdiction of another corporation. In the future as in the past it will, doubtless, run its wires through conduits provided either by itself, or companies interested with it, and do all in its power to prevent its competitors from enjoying the same privilege.

The daily press of this city has done all in its power to encourage the enactment of compulsory underground laws; it has approved of the appointment of a commission to enforce them, and it has hounded its members because they did not cause the wires to be buried at the appointed time. It has stood calmly by, while the necessary legislation for the formation of an underground monopoly was pending, and has failed to utter one word of protest against such a measure. Now at the last moment when the two great telegraph and telephone corporations, whose financial success depends upon their shrewd management, are said to have secured a controlling interest, the people are warned that electrical competition will be throttled, and that the great boon which was to be derived from the burial of the wires is a delusion and a snare.

As yet there is no positive information that the proposed subterranean system of the city is to pass under the management of existing electrical companies, yet it may readily be assumed that such a state of affairs is not unlikely, and it should have been properly guarded against. The original act was, however, crudely drawn, and subsequent legislation has not been in the direction of reform. Neither the salaries nor expenses of the commissioners were provided for, and as the records will bear witness, the whole matter has been managed in a bungling manner from its very inception.

PUBLIC INTEREST IN TELEPHONE LITIGATION.

In deciding that it is within the province of the national government to bring suit to determine the validity of the Bell telephone patents, secretary Lamar has assumed the very questionable position of stimulating various speculative enterprises, whose only excuse for existence is the acquisition of money from the sale of shares which are utterly valueless, whatever may be the outcome of the trial.

Heretofore the income derived from this source has been mainly utilized in litigation with the American Bell Telephone Company ; therefore, in transferring this burden to the government, the various claimants are enabled not only to effect a considerable saving in their expenses, but to give their cause an appearance of legitimacy to which it is not entitled upon its merits.

Having been driven from one line of defenses to another, their resources well nigh exhausted, with little hope of securing fresh victims from whom to obtain the sinews of war, the national government is finally appealed to, in the ultimate effort to bolster up this tottering aggregation of speculative schemes.

Unfortunately the popular mind is prone to jump at conclusions regarding a question of this character, especially where ingenious efforts are continually made through the press to create the impression that the introduction of new evidence will in some mysterious manner change the records of fact, which have heretofore successfully resisted all attempts to upset them.

Whether local telephone companies demand from their subscribers a rental of one dollar, or of one hundred dollars per month, has no bearing whatever upon the validity of the Bell patents. Neither would their cancellation bring with it that much-talked-of boon, a cheap and satisfactory telephone service. If the royalty exacted by the American Bell Telephone Company was entirely abolished, and instruments supplied to its licensees without money and without price, the actual cost of providing a satisfactory exchange service would exceed the figures which are frequently mentioned as the proper maximum rental to subscribers. The nature of the telephone business does not require the intervention of the national government to protect the people. The telephone is not a necessity of the masses to the same extent even as the telegraph.

If there be any man whose prosperity and happiness depends upon his being the user of a telephone, such an instrument is worth to him what he pays for it, otherwise he would discontinue its use.

The precedent now established, if confirmed by the courts, will prove an unending source of annoyance to future inventors, as well as to the government itself, especially where patents attain exceptional value. As the validity of the patent would have been tested before the supreme court in due course of time, and as the counsel of the American Bell Telephone Company had proposed to its opponents to join hands with them in an effort to hasten its presentation before that final tribunal, there was no valid excuse for a movement of this kind excepting the probability of bestowing a fictitious value upon worthless shares, or possibly the establishment of sufficiently formidable rivals in the business, which might eventually be bought out to the pecuniary advantage of those public-spirited gentlemen who are ever anxious to protect the people from the encroachments of a grinding monopoly, always provided that they are not personally interested in it.

ELECTRICITY FOR THE ELEVATED ROADS.

While a great deal has been said and written as to the practicability of utilizing electricity for motive purposes on the elevated road, there has been an apparent lack of information as to the work to be done, and the difficulties to be overcome. The very thorough manner in which the whole subject has been examined by a gentleman who is not only capable of grasping the problem, but has had every opportunity and incentive for doing so, may be learned by reading his paper upon the subject which is published in our present issue. Perhaps the most important point touched upon by Lieutenant Sprague, is the greater carrying capacity to be attained without augmenting the strain upon the structure, or the liability to accident, which must attend

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any considerable increase of the present facilities with the use of steam locomotives. It is in this direction which he looks for success, rather than to the more economical use of fuel in the stationary engine, or the possible utilization of less highly skilled labor. The practical experimenting which has already been done on the Ninth avenue line by another inventor, although a praiseworthy exhibition of faith and perseverance, is not calculated to offer any relief to the railway management for the overburdened condition of the Third avenue road. The simple substitution of an electric for a steam locomotive, while a possible advance so far as cleanliness and safety is concerned, does not afford a sufficient margin of economy to warrant its adoption for such a service, however suitable it may prove for other purposes.

The interest of the public in this question is greater than appears without thoroughly examining it. Enlarged facilities, reduced wear and tear to the structure, and a proportionate decrease in operating expenses will tend towards better accommodations, with a possible reduction of fares, although the latter, even outside of commission hours are by no means exorbitant.

Certain mechanical journals appear to view this question from a selfish standpoint, as if an encroachment was to be made by electricity upon the domain of steam. It has even been asserted that the use of electricity for operating railways will be impracticable because of the loss in transferring power, hence it will be unprofitable until it is produced independently of steam. Every electrician whose opinion is worth anything is perfectly familiar with these natural laws, and thoroughly appreciates the merits of the steam engine. It is not, however, possible to apply its power direct in all cases. Belts, gears, ropes, compressed air, and other devices are used, and now the claims of electricity for the transmission of power are being investigated. It is generally understood that it possesses the necessary advantages to render it available in many cases, and it is confidently believed that it will be found adapted for many classes of railway work, among which are included the New York elevated lines.

Stationary engineers at least should have no reason to complain of the growing uses of electricity. They will eventually find it greatly to their pecuniary advantage to understand, and care for the electric machinery placed in their charge. As for the locomotive engineers, they have for many years evinced a remarkable capacity for protecting their own interests in a far more efficacious manner than can be accomplished by their editorial friends, among whom we desire to be included.

PROSPECTS OF LONG-DISTANCE TELEPHONY.

While the early predictions regarding the future of long-distance telephony have not been fully realized, a vast amount of experimental work has been done in that direction, and the results already attained have been sufficiently successful to warrant its application to a practical commercial undertaking. The Massachusetts legislature having refused to authorize an increase of the capital stock of the American Bell Telephone Company for the avowed purpose of engaging in the exploitation of this branch of the telephone business, the American Telephone and Telegraph Company, an independent corporation, has been organized under the auspices of the home company, which will hereafter prosecute the work.

It has been definitely settled that the long-distance telephone cannot be a competitor of the telegraph, in the sense of becoming a general substitute, or even an improvement upon it. It is fully believed however, that there is a special field for it in connection with modern commercial enterprise, to which the attention of its promoters has long been directed.

Large mercantile firms and manufacturing corporations, with partners or agents at distant points, frequently require business consultations, which with the now perfected apparatus and lines can be carried on without annoyance. With the assistance of competent stenographers at each point, who are considered indispensable in modern counting-rooms, permanent records of such councils may be taken, and the transaction of business generally facilitated. New England manufacturers having agencies in New York and Boston, have for over a year utilized the telephone for daily oral communication between such distant points, paying a fixed annual amount for the privilege of two daily sessions.

Preparations are now being made to establish a similar system of communication between New York and Philadelphia. It must not be supposed that the difficulties increase with the distance covered. The conductor used being of copper, is connected as a metallic circuit, the direct and return wires being stretched parallel and immediately adjacent to one another; the lines constructed in the best possible manner, and with instruments adapted to the work, telephonic communication between points one hundred miles apart may be even superior to the ordinary local service in large cities. Indeed it appears probable that if the same perfection is maintained in the future development of long-distance telephony as a business, subscribers will be led to inquire as they now do regarding the telegraph, why it is that communication with distant points is so much more satisfactory than within the boundaries of an ordinary municipality.

It has been frequently intimated that the development of the long-distance telephone has been purposely retarded for the protection of the interests of the Western Union Telegraph Company, as required by its agreement with the American Bell Telephone Company. In order that the exact state of the case may be understood, an extract from the contract is given herewith.

Article 13. (1) The right to connect telephonic district or exchange systems for the purpose of personal conversation between persons at the instruments, and the right to use telephones on all lines not forming a part of a telephonic district or exchange system for such personal conversation (except so far as licenses are to be granted to the party of the first part under article 14) *are to remain exclusively with the party of the second part, and those licensed by it for the purpose.* But such connecting and other lines are not to be used for the transmission of regular business messages, market quotations or news for sale or publication over *lines owned by it* or by *corporations in which it has a controlling interest,* nor license the use of its telephones or patents for the transmission of such general business messages, market quotations or news for sale or publication in competition with such telegraph business of the Western Union Telegraph Co., or that of the Gold and Stock Telegraph Co.

(2) The terms "general business messages" and "telegraph messages" or "messages for hire," are defined to mean all communications in behalf of *other* parties than those who directly communicate by the telephone by themselves or their servants or agents personally present at the instruments; and no person engaged in the business of transmitting messages for other parties shall be authorized or knowingly allowed by the party of the second part, or its servants or agents, to transmit such messages through the telephone.

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ARTICLES.

APPLICATION OF ELECTRICITY TO PROPULSION ON ELEVATED RAILROADS.[1]

BY FRANK J. SPRAGUE,

Electrician Sprague Electric Railway and Motor Co.

WHEN, only a few years since, against all the hue and cry of its opponents, but in answer to the growing demand for rapid transit, the elevated railroads in New York were projected and finally constructed, I doubt if their most ardent supporters looked forward to the fact that in 1885 the roads could not accommodate the number of passengers who wish to be carried. But so great has been the growth of the city, so rapidly has the business section pushed to the northward and forced large numbers of the people, especially the laboring classes, to seek homes at the upper limits of Manhattan Island, where rents, already increasing because of increased facility of access, are still lower than could be readily commanded for business purposes in the lower part of the city, that the roads at night during the commission hours are now taxed beyond their present resources, and the demand is urgent that their carrying capacity be increased, or that new routes be opened for the accommodation of the public. But new roads require time for construction. Undoubtedly there will eventually be an underground system, and for through traffic this presents the most satisfactory solution, but for a score of reasons unnecessary to mention here, this road is one of the future, not of the present. Yet the city is growing rapidly, homes are pushed further and further to the north, and the great army of workers who must every day travel from end to end of the city is steadily increasing. Most urgent, then, is the necessity for additional means of transportation, and, for the present at least, by the elevated railroads.

There are four of these: the Second, Third, Sixth and Ninth avenue lines, the last two merging into the Harlem extension.

In considering how the capacity of the roads may be increased it is necessary to note the character of the roads and their method of operation, and for that purpose we will take the Third avenue line as an example. This extends from the Harlem River to South Ferry, and has a length of about eight and a half miles. With the main features of the construction of the road-bed you are all familiar. It consists of a series of built-up wrought iron columns of various heights, the bases resting in solid stone foundations and supporting a superstructure of lattice girders, making up a very strongly braced web system, on which are laid the ties and rails of a complete double track road, with all the necessary arrangements of switches and sidings.

Because of the undulatory character of the streets, the road-bed is a continuous succession of widely varying grades with frequent short level spaces. The grades vary from 8 to 105 feet to the mile, and the aggregate of the level stretches amounts to about one-third of the whole distance. Almost all stations are at level grade, and hence a good portion of the aggregate is at points at which power is not applied for traction. As an example of the undulatory character of the road, take the section from Fifty-ninth to Ninety-eighth street. Leaving Fifty-ninth street on the up track the grade runs almost immediately at 80 feet to the mile for a lineal distance of about 1,800 feet. Then comes a level stretch for 1,100 feet, a 100-foot down grade for 1,300 feet, another level of 900 feet, a 95-foot up grade for 1,500 feet, a level of 1,700 feet, a 105-foot down grade for 2,200 feet, a short level, and so on throughout the whole length of the road.

In the 17 miles of single track there are altogether 52 stations. A train weighing, as often happens, over 90 tons, must make the trip from South Ferry to Harlem River in about 42 minutes, including stopping at 26 stations and discharging and taking on passengers. This is at the rate of only about 10 traffic miles per hour. Surface railroads stopping at any street corner make six miles per hour. Hence it is evident that the elevated railroads cannot afford to make any slower time than at present. If they could run faster their traffic would be very materially increased.

A moment's consideration, then, will show the remarkably difficult character of the work done by the engines on the elevated railroads. Three times in every mile they must start a weight oftentimes as high as 90 tons from a dead rest, raise it up to a speed of nearly 20 miles an hour, propel it a short distance at that speed, overcoming not only inertia of the train and the traction which is required for the train on a level, but also climb steep grades, and then suddenly bring the train to a rest. All this must be done in a minute and a quarter of time. Of course this work varies greatly between every station, being much less between those stations where there is a down grade. Without now going into the details, which I will give later, the mean work of the locomotives is three times that necessary to draw the train at its mean speed of about 15 miles an hour on a level grade, and in getting under way and climbing the 105-foot grades, the work of the locomotive is at least seven times that required for the mean speed traction on a level.

The acceleration of the train on the down grades and the momentum stored up in the train in getting under way play but little part, except on the down grades, in propelling the train, because the stoppages are so frequent and are made in such short distances that advantage cannot be taken of much of this stored up energy. Hence the large proportion of this is thrown away.

With cars of a seating capacity of 48 and room to accommodate 40 more standing, it is evident that the capacity of each car of the train cannot well be increased, and the capacity of the trains can only be increased by increasing the number of cars. There are already 63 trains in operation at one time on this road during commission hours, they run at very close intervals and they must be under the most perfect control. Every car added increases the momentum of the train, rendering it more difficult to quickly and efficiently check the speed, and increasing the liability of, and the danger from, any derangement of the brake apparatus, especially where dependent upon one source. If the length of trains be increased, admitting that they can be handled without difficulty, the engines will be forced to a duty much beyond that for which they were constructed.

The following details of an indication of power taken on the Sixth avenue road from an engine similar to those in use on the Third avenue will be of interest:

Cylinder, 11″ diameter, 16″ stroke.
Driving wheels, 42″ diameter.
Speed, 15 miles per hour.
Boiler pressure, 130 lbs.
Average effective cyl. press., 100 lbs. (by indicator).
Indicated horse-power, 2 cylinders.... 184.3 h. p.
Deduct 10 per cent. for friction of engine 18.4 h. p.
Net for traction.......... 165.9 h. p.
Net tractive pull, 4,147 lbs.

Mr. Angus Sinclair, in experiments recently conducted on the Third avenue line, found that the mean cylinder pressure for all the time steam was on the cylinder for a round trip was 81.7 lbs. and the mean horse-power indicated was 163.4.

These are high effective pressures and powers for engines of these dimensions.

Furthermore, when the tracks are in a slippery condition, the weight of the engines does not now give sufficient rail adhesion to promptly get away from the stations. An additional car will render this delay more frequent and tend to reduce the traffic miles per hour run during com-

1. Read before the Society of Arts, Boston, Mass., December 10, 1885.

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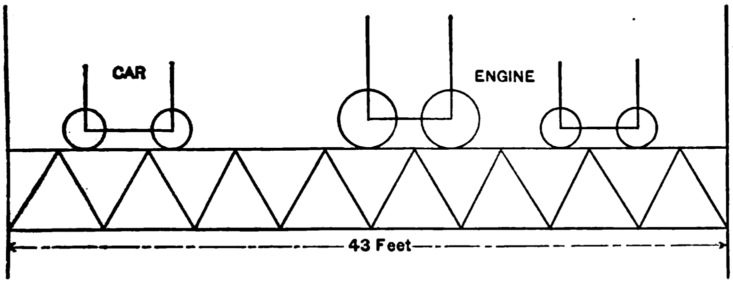
mission hours. To get increased traction in the present system it is absolutely necessary to increase the weight of the locomotives, but such increase of weight is useless unless it be effective on the drivers, but if effective on the drivers then we have an increased dead weight applied to the superstructure of the road at one point.

Four things at least operate against the superstructure of the elevated railroad; first, the thrust of moving weights ascending the grades tending to vibrate the structure; second, the vibration due to the shifting of the weight along the girders between the columns, which is very much greater with the locomotive than with a car because of its greater weight, the traction exerted by its wheels, and the reciprocal thrust on the drivers; third, the crushing strain on the columns and the tensile strain on the girders, the latter greatest, of course, when the weight is midway between the columns; fourth, the shearing strain on the rivets. These cause the repairs and occasional reinforcements found to be necessary to the superstructure of the Third and Sixth avenue elevated roads made more necessary by the increased travel. These repairs are of course a heavy charge against the operating expense of the roads.

How, then, is the capacity of this road to be increased? It certainly ought not to be done by increasing the traction of the locomotives. This is out of question, for leaving out of consideration the impracticability of a change of the locomotives, it would be impolitic and unwise to increase their weight. Attention to the following diagram will explain why it is so:



This is a diagram of a lattice girder between two columns, a distance of 43 feet, and shows the distribution of weight when one of the standard engines has its drivers nearly in the centre at equal distance from the columns. These are shown by the large circles. On the right are the trucks of the engine. On the left is the forward truck of a loaded car. This distribution gives the greatest shearing strains on the rivets. The locomotive weight is 22½ net tons, or 45,000 pounds, of which 15 tons only are carried by the drivers and are effective for tractive power. The other 7½ tons are supported by the trucks. One-half the weight of the car following is about 17,500 pounds. This gives a total weight of 62,500 pounds, or 1,454 pounds per running foot between columns. Any increased weight to increase the traction of the locomotive will increase the strain at the weakest point of the structure.

It is necessary to keep up the high character of the engineering work of this road; every consideration of prudence and safety and public interest requires that under no circumstances or conditions shall the strain on the chords, or braces, or rivets exceed a perfectly safe limit. The road has been remarkably free from accidents of this character, notwithstanding the great number of trains and the hard conditions of service. This is, of course, due to good engineering work in the beginning, and to a very careful and critical system of administration, inspection and repair. It is evident then that we ought not to increase the weight of locomotives since the shearing safety limit has been nearly reached.

Two ways, however, remain by means of which the capacity of the roads can be increased; one, by increasing the number of cars in a train, provided it can be done without increasing the weight of the tractive engine, or if it can be distributed and the train remain under perfect control; another, by increasing the mean running speed. Increasing the length of the train will not produce any very much greater strain on the structure, because the columns are only 43 feet apart, and the cars are about 46 feet long, so that the weight of a dozen cars would not increase the shearing or tensile strains beyond that due to two cars; the period of such strain of course would be somewhat lengthened, but this is immaterial if the elastic limit be not reached. The longitudinal vibration due to this cause will be increased, but if we can do away with the vibration caused by the locomotives, the total vibration would be much less. It is the shearing and tensile strains between the columns that we must be careful not to increase. To get a higher speed of the trains it is probably necessary to increase the power, and at the same time to increase the traction. This increased traction, however, must be distributed, it cannot be put at any one point.

It is not practicable to materially increase the number of trains during commission hours, because they run nearly as closely as can be now to make their running time.

We see, then, that steam locomotion does not present many opportunities to better the condition of the road. Hence we are obliged to turn to some other method of locomotion, and that which promises the most satisfactory solution is an electrical system.

I have for a long time been elaborating such a one, and am now convinced that this is the future method of propulsion for the trains of the elevated roads, and it is a near future.

In the substitution of one system for the other on these roads what is the object sought? Ultimately, of course, it is to get a greater return for a given investment, and it is to be obtained in one or more of three ways.

First. By decreasing the coal expended per passenger carried if this is practicable.

Second. By reducing the wear and tear of the motive power, but more particularly that of the road-bed.

Third. By increasing the carrying capacity of the roads.

The saving of labor I do not think one of the objects to be particularly striven for, the safe handling of passengers and trains probably never requiring a less number than are now necessary.

Much has been said about the great saving of fuel. The work of the present engines has been much underestimated, and consequently the expenditure of coal per horse-power much exaggerated, some statements making this as high as 20 to 25 lbs. per horse-power hour. This is a most serious mistake, and one of which no engineer or electrician should have been guilty. On the contrary, the present engines, considering the conditions under which they are used, show a remarkably high efficiency, for while on duty 20 hours, and with steam admitted to the cylinder for 6 hours only, they show a horse-power per hour developed for an average expenditure of about six pounds of coal. Under the best conditions they must be developing a horse-power with only about five pounds of coal. I will show later on the expenditure in detail, from which it will be seen that the saving in coal is not the chief object. In a proper electrical system there will be, as I will show, a very material decrease in coal expenditure, but I repeat this is not primarily the object to be sought.

It is evident that if any decrease in the wear and tear of the superstructure can be accomplished a great saving will result.

By a system of electrical propulsion the power can be distributed underneath the cars—every car, or two cars if need be, being a unit—and at the same time arrangements can be made for propelling five or six cars under simultaneous control.

By distributing the power under the car, the whole weight of the car and passengers can be made effective for traction, such traction weight being six times as great as

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is afforded by the present locomotives. This will enable the cars to be started more promptly, brought to speed more quickly, and stopped in shorter intervals, increasing the mean rate of speed, and thereby the capacity of the road.

Weight is the necessary practical adjunct for traction. The elevated roads present a peculiar problem. To attempt to solve that problem by replacing the present locomotives by electric locomotives of lighter weight, or even of the same weight, is to shut our eyes to plain mechanical and engineering truths, and does not advance by one single step such solution.

The making of cars individual units of locomotion will enable the intervals between trains to be made one-third of the present schedule for a large part of the time. This would greatly increase the number of passengers during the day and night who would make use of the elevated roads, and this too, without materially increasing the running expenses.

Another important advantage will be the great reduction in the vibration and wear and tear of the superstructure by distributing the weight so much more evenly. The weight upon the lattice girders between columns would always be less than two-thirds, sometimes only one-third that now existing, the vibration, tensile and shearing strains being in nearly the same proportion. The motion of the moving parts being rotary the train would start more smoothly, and the motive power be less liable to derangement. Slipping or skidding such as is now common both in starting and stopping would be unknown.

The objects thus far indicated as attained are important, and some of them would be very instrumental in the accomplishment of that most immediate and pressing object, the increasing of the carrying capacity of the road without reducing the time schedule.

This must be done, even if the operating expenses are increased. I am glad to say that it can be done with a decrease of these. It is a problem requiring some thought. There has been a great deal of Keelyism in connection with this subject. So much has been said about the ease with which the elevated trains could be operated by electricity, so many promises have been made, so many unreliable statements have found their ways into the press, that people have been led to believe that the change from the steam to an electrical system of locomotion would be quickly and readily made, and I must confess my own opinion that some of the projectors of electric railways have reckoned without their host, and have very much underestimated the character of the work which they have undertaken to perform.

Let us see what power is actually developed on the Third avenue road during commission hours. I will investigate the distribution of the power on this road in such detail as is necessary to show clearly what is going on there, and I have made a number of mathematical determinations, to which I invite your attention. Through the courtesy of chief engineer Robert I. Sloan, of the Manhattan company, I have been allowed a profile sketch of the Third avenue road, from which I get much of my information.

The work of the engines on the elevated road may be divided into three parts:

1st. That necessary to overcome the train's inertia, to start it from rest and raise it to its mean maximum running speed, is deduced from the mathematical formula $\frac{wv^2}{2g}$ for foot lbs., where

v = velocity in feet per second;
w = weight in pounds;
g = value of gravity (32.2).

2d. The work of lifting the train from level of low to that of higher grades. This is WH, where H is the total height through which weight W is lifted.

3d. The work of traction. This is obtained by using .004 as the factor of traction, or eight pounds per net ton, which is a fair allowance for good rolling stock. This traction is only considered as exerted on level and up grades, less the traction during the period of slowing to stop. On down grades the energy of falling is more than sufficient for traction.

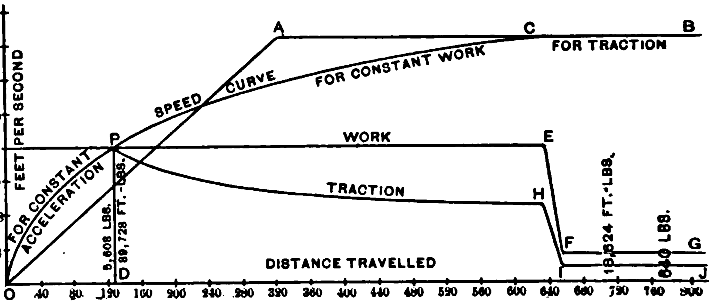
The main line of this road, from South Ferry to Harlem, is 8.48 miles long. The following are details of this line, not including the branches at City Hall, Thirty-fourth, and Forty-second streets:

Length of line	8.48 miles.
Total lift, up grade, up track	144.42 ft.
Lineal distance for same	13,160 ft.
Total lift, up grade, down track	137.60 ft.
Lineal distance of same	16,510 ft.
Level on each track	15,100 ft.
Number of stations	27
Number of stoppages	26
Number of stations at which stops are made at level or up grade, each track	20

Average times:

Single trip	42 minutes.
Per station	97 seconds.
Underway	80 seconds.
Stop	17 seconds.

Attention to the accompanying diagram will explain something of the actual engine performance.



This is a diagram for the first 800 feet, on a level.

The distance run is measured along the line O X—the speed per second along O Y. The latter scale is ten times the former. O P C B is the resultant speed curve, and is a combination of two curves. When getting away from a station an engine exerts for a short distance a nearly continuous traction, which soon begins to decrease, until, when it has run about 130 feet, it has gotten up to a trifle over half speed, at which time it is doing its full work per second, this work being expended in accelerating the speed of the train, and in traction.

This part of this curve O P, then, is for a nearly uniform acceleration of speed of about one foot per second, extends over a lineal distance of about 130 feet, and about 16 seconds of time. The engine now working to its full capacity, the curve from P to C is a curve of decreasing acceleration, the work remaining the same until the maximum speed is reached at C. This I find to be about 29.1 feet per second, and is reached about 625 feet from the station.

From O to P the work gradually increases; at P it becomes constant, and so remains as long as the speed is accelerated, that is, to C, as represented by line P E.

When the full speed is reached the work suddenly falls off, as does the traction, because energy is no longer stored up in the train, but simply expended in traction. This continues until within about 289 feet of the station, when brakes are applied and the train is brought to a rest. This distance of 289 feet, about once and a half the length of a train, the maximum speed obtained, the distance traveled over, and the running time between stations, are mutually dependent.

As stated, this diagram and description are based on a level between stations, and the grades entirely change it, but it suffices for illustration.

With the above assumption, the distances are as follows:

Average between stations	1,722 ft.

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Divided nearly as follows :

Getting up to a little over half speed	130 ft.
Thence to full speed—about	495 ft.
Full speed	808 ft.
Slowing to stop	289 ft.

The average speed in feet, per second, would be :

Getting under way	19.7
Full speed	29.1
Slowing to stop	14.1
Mean between stations	21.3

The average speed in miles, per hour :

Getting under way	13.4
Full speed	19.2
Slowing to stop	9.6
Mean between stations	14.7

Distance traveled while slowing to stop :

At 20 stations	5,780 feet.
At 6 stations	1,734 feet.

Effective traction distances :

Up track, 13,160 + 15,100—5,780 =	22,500 ft.
Down track, 16,510 + 151,600—5,780	25,830 ft.

The official weights, in lbs., are :

Empty car	23,850
80 passengers, at 130 lbs	11,180
Motive power per car (electrical)	4,950
Total of loaded car	39,980

Weight in net tons :

Loaded car	20
Train of four cars	80

Energy required in overcoming inertia alone in getting underway :

$$\frac{80 \times 2{,}000 \times (29.1)^2}{33{,}000 \times 64.4} \ldots\ldots\ 63.8 \text{ h. p.}$$

To get the *capacity* of the engine we have the speed of trains accelerated one foot per second when running from say $15\frac{1}{2}$ to $16\frac{1}{2}$ feet per second.

The foot pounds expended per second in overcoming inertia then would be :

$$\frac{80 \times 2000 \times (16\frac{1}{2}^2 - 15\frac{1}{2}^2)}{64.4} \quad 79{,}488$$

The foot pounds expended in traction for the same period would be :

$$80 \times 8 \times 16 = 10{,}240$$

The sum is 89,728

Hence the net motor capacity is :

$$\frac{89728}{550} = 163.1 \text{ h. p.}$$

Plus five per cent friction, gives a motor capacity, per train, of .... 171.3 h. p.

Or 43 *h. p. per loaded car.*

Plus another five per cent friction gives necessary *engine capacity* for 80 ton train of ..... 179.2 h. p.

For any given grade and weight of train within the limit of speed considered the tractive strain is a constant.

For 80 tons on a 105-foot grade this tractive strain is 3,822 pounds.

A net motor capacity of 163.1 h. p., developing 89,728 foot pounds of effective work, is then sufficient to pull an 80 ton train up a 105-foot grade at the rate of $\frac{89728}{5822} = 23.5$ feet per second, or 16 miles per hour.

Total energy per single trip in overcoming inertia :

26 × 63.8 plus five per cent friction	1,742 h. p.
Or per round trip	3,484 h. p.

Energy of lifting, up trip :

$$\frac{80 \times 2000 \times 144.42}{33000} = 700 \text{ h. p.}$$

Plus five per cent. friction	735 h. p.
Energy of falling, down trip	700 h. p.

Energy of lifting, down trip :

$$\frac{80 \times 2000 \times 137.6}{33000} = 667 \text{ h. p.}$$

Plus five per cent. friction	700 h. p.
Energy of falling, up trip	667 h. p.

Total work of lifting the train on round trip,
735 + 700 .... 1,435 h. p.

Since momentum of train is more than sufficient for traction on down grades and while slowing to stop, work of traction is only debited to motor on level and up grades less the space traveled over in bringing train to rest.

Up to the speed attained and with the excellent rolling stock used, the traction may be taken as eight pounds per net ton.

The *energy of traction* thus expended would be :

Up trip,

$$\frac{80 \times 8 \times 22500}{33000} = 436 \text{ h. p.}$$

Plus five per cent. friction .... 458 h. p.

Down trip :

$$\frac{80 \times 8 \times 25830}{33000} = 501 \text{ h. p.}$$

Plus five per cent. friction .... 526 h. p.

Total work of traction 458 + 526 .... 984 h. p.

Résumé of work expended during one round trip in 33,000 foot-pound units :

Starting, up track	1,742 h. p.
Starting, down track	1,742 h. p.
Lifting, up track	735 h. p.
Lifting, down track	700 h. p.
Traction, up track	458 h. p.
Traction, down track	526 h. p.
Total	5,903 h. p.

or briefly,

Starting	3,484 h. p.,	or	59.0 per cent.
Lifting	1,435 h. p.,	or	24.3 per cent.
Traction	934 h. p.,	or	16.7 per cent.
	5,903 h. p.		100 per cent.

Average per minute for round trip ... $\frac{5903}{84} = 70.3$ h. p.

Average per minute running time .... $\frac{97}{80} \times 703 = 85.2$ h. p.

At the busiest time there are 63 *trains in operation, whence we have for the total power developed in motors at one time—*

$$63 \times 70.3 = 4{,}429 \text{ h. p.}$$

These determinations have been made to include 5 per cent. friction for electric motors. For locomotives friction is counted as 10 per cent.

This would give a total of 4,640 *h. p. per minute for the steam plant, for a single round trip an expenditure per train of,*

$$5{,}903 \times \tfrac{1}{21} = 6{,}184 \text{ h. p.}$$

With present steam plant, one engine—

Makes, round trips	9
Uses, lbs. of coal	5,760
Is on duty, hours	20
Uses steam, hours	6
Average consumption per trip, lbs	640

We have

Total horse-power per round trip	6,184
Horse-power per pound of coal $\frac{6184}{640}$ =	9.66
Pounds of coal per horse-power per hour $\frac{60}{966}$ =	6.21

I have neglected the amount of steam used in braking. Also the slowing down and speeding up again when following close to other trains, and the losses while standing still both from radiation and escaping steam. These items will reduce the coal expenditure to less than 6 lbs. Since it costs about $4 per gross ton to put the coal on the engines, and they use 640 lbs. per round trip, it will be seen that the coal expense is only about $1.15 per round trip, including waiting time, an average of $2\frac{1}{4}$ cents per station. One additional passenger at every other station during commission hours or one every fourth station at other hours would pay the coal expenses of the trip. From this it will be seen how important it is to increase the carrying capacity, whether with or without an increase of coal expended.

In a steam plant an 80-ton train has the weight distributed as follows :

Locomotive $22\frac{1}{2}$ tons	45,000 lbs.
4 cars at 23,850 lbs	95,400 lbs.
151 passengers, at 130 lbs	19,630 lbs.
	160,030 lbs.

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The 80-ton electrical train has weights distributed as follows:

Motive power, 4×4,950—	19,800 lbs.
4 cars at 23,850 lbs	95,400 lbs.
344 passengers at 130 lbs	44,720 lbs.
	159,920 lbs.

The electrical train of this gross weight will carry double the number of passengers. If the steam train should carry the same number of passengers, 344, that an 80-ton electrical train will carry, its weight would be—

160,030+(193×130) =	185,120 lbs.
Or nearly	92.6 tons.

During commission hours the weight of electrical train per passenger is $\frac{159920}{344} = 465$ lbs. The excess of weight of a steam train over an electrical train when carrying 344 passengers is 25,200 lbs. This distributed in an electrical train gives an additional passenger capacity during commission hours for the same gross weight moved of—

$$\frac{25200}{465} = 55 \text{ passengers per steam train.}$$

For 63 trains, four cars each, there would be $54 \times 63 = 3,402$ through passengers—or double that number of way passengers—at one time.

A steam locomotive of the type considered has 30,000 lbs. weight on the drivers, hence its tractive weight is 15 tons.

An electrical train having the motive power distributed has an effective tractive weight of 80 tons, or 20 tons per car.

In an electrical system such as I have devised, a large proportion of the energy of the trains is recovered when slowing to stop and on down grades. This is accomplished by a method of braking which consists of being able at will to convert the energy of the moving train into electrical energy and deliver to the line, and by the same apparatus which controls the speed and power of the train. On a double track road the energy given to one track may be communicated to the other as well as along itself. The up grades of one track being balanced by the down grades on the other track, it is evident that the total up grade of a system is equal to the down grade thereof. Therefore, energy being expended in getting under way and climbing up grades, and a large proportion given of this being given back in stopping and running on down grades, it is evident that the energy required in the system is that necessary to move the trains continuously on level grades with a percentage for loss in conversion and reconversion added.

This is one of the very great advantages of an electric railroad where grades and stoppages are frequent, and a large number of trains are operated.

By this method referred to it is an easy matter to reduce the speed of a train to a third or fourth of its maximum, the braking power being under perfect control. If, say, to one-third speed, then since the energy of a moving body is proportional to the square of its velocity, eight-ninths of the train energy is available for the first step of braking; that is,

$$\tfrac{8}{9} \times 63.8 = 56.7 \text{ h. p.}$$

The remaining 7.1 h. p. is easily taken care of.

At least 75 per cent of this 56.7 h. p. will appear as current delivered back to the line.

$$75 \text{ per cent. of } 56.7 = 42.5 \text{ h. p.}$$

In 52 stoppages there will be saved.

$$52 \times 42.5 = 2,210 \text{ h. p.,}$$

of which 80 per cent. will again appear as effective tractive work on the axles—that is, it will relieve the main generating station of a supply of that power.

$$80 \text{ per cent. of } 2,210 = 1,768 \text{ h. p.}$$

Also 75 per cent. of all the energy of falling, in excess of traction, will appear in the form of current, of which 80 per cent. will become effective for tractive power, as follows:

We have for the

Up track:

Lineal distance down grade	16,510 feet.
Stopping at 6 stations	1,724 feet.
Difference — distance for traction	14,776 feet.
Traction, $\frac{80 \times 8 \times 14,776}{33,000}$	286 h. p.
Energy of falling	667 h. p.
Excess of energy of falling over traction	381 h. p.
Current energy returned, 75 per cent. of 381	286 h. p.
Effective work appearing, 80 per cent. of 286	229 h. p.

Down track:

Lineal distance down grade	13,160 ft.
Stopping at 6 stations	1,724 ft.
Difference distance for traction	11,426 ft.
Traction, $\frac{80 \times 8 \times 11,426}{33,000}$ =	221 h. p.
Energy of falling	700 h. p.
Excess of energy of falling over traction	479 h. p.
Current energy returned, 75 per cent. of 479	359 h. p.
Effective work appearing, 80 per cent. of 359	287 h. p.
Total recovered, 229 + 287 =	516 h. p.

There is, then, in this electrical system recovered in effective work and again applied to driving the train, for each round trip, as follows:

Stopping, up and down tracks	1,768 h. p.
Down grades up and down tracks	516 h. p.
Total	2,284 h. p.

We have power:

Expended for train, round trip	5,903 h. p.
Net recovery	2,284 h. p.
Net expended	3,619 h. p.
Average per minute round trip	43.1 h. p.
Average per running minute	52.3 h. p.
Total for 63 trains, 64×43.1 =	2,715 h. p.

This is the net effective power at the trains which is required to operate 63 trains of 80 tons each, as against 4,640 h. p. in the present steam plant, *a difference of* 1,925 *h. p., or* 41 *per cent. in favor of the Sprague system.*

But the electrical power must be generated at one or more central stations, transmitted to the motors, and then reconverted into mechanical work—the original mechanical work of the engines suffering from two conversions and one transmission. Experience shows that with a good distribution and properly constructed motors, 60 per cent. of the original will appear in effective work on the car axle.

Then for any electrical system not using the Sprague system of braking, but with other losses the same, there will be required at the central station,

$$\tfrac{100}{60} \times 4,429 = 7,382 \text{ h. p.}$$

With the Sprague system, nearly every motor coming to a station or running down-grade, becomes a generator which is helping to supply the current needed to operate the remaining trains.

The method has already been shown to save about 40 per cent. as against any other electrical system.

Instead of the current being all supplied by the main generating station at one or two points, it is supplied from nearly as many moving stations distributed along the whole line as there are trains slowing down or running on down grades.

With any given size of conductors, and average potentials, this would greatly reduce the loss, or with the same percentage of loss on line, the main conductor would be very much smaller, because less current is supplied from the central station, and it is transmitted a shorter distance.

The relative size of conductors necessary would be about as 100 is to 45, a saving of 55 per cent. in favor of this system.

In the Sprague system there would be required at the central stations

$$\tfrac{100}{60} + 2,715 = 4,525 \text{ h. p.}$$

something less than that developed on the present locomotives, which is .... 4,640 h. p.

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That is, the losses of two conversions and one transmission is more than counterbalanced by the amount saved in this system of braking.

The *original steam power* then would be:

Present steam plant	4,640 h. p.
Any other electrical system	7,382 h. p.
Sprague system	4,525 h. p.

Now as to the cost of coal in the present steam and the Sprague electric system:

The present engines have to use a very good grade of coal. After delivery, every ton of this has to be carted, hoisted, stored, again handled and put on to the engines. The coal must then cost about $4 per ton when ready for use.

The engines expend, as shown, about 6 lbs. net of coal per horse-power per hour.

Large stationary engines can be relied on to develop a horse-power per hour on three pounds of a lower grade of coal, such as a mixture of anthracite dust and bituminous or Cumberland coal if burned in a good boiler with, say, a Jarvis setting. This mixture can be delivered to the furnaces for $2.50 per ton.

The ratio of expenditure for coal, then, would be expressed by the fraction:

$$\frac{4640}{4525} \times \frac{6.00}{3.00} + \frac{4.00}{2.50} = 3.50.$$

That is:

For every $3.50 spent for coal in the present steam plant, there would be expended $1 in the Sprague system of electric railroads—a saving of over 71 per cent.

Against this and some present labor expenses must be put the cost of running the central stations.

Another consideration which must be taken into account when a part of the energy of the trains is returned to the line as I have described, is the great saving in the original investment at the central stations as well as in the conductors. In the particular instance here given there is a difference in the power to be provided for at the central stations of 7,382 — 4,525 = 2,860 h. p.

The saving on this would for lots, buildings, boilers, engines, dynamos and fittings, be not less than about $150 per horse-power, or $429,000. There would be nearly a proportionate saving in the labor, depreciation, and the incidental expenses of the central station.

Again, since the motor system affords a very perfect system of braking, neither vacuum or pressure brakes need be used, although the hand brakes would of course be retained.

As a somewhat remarkable corroboration of theoretical by practical work, I would refer to the account of Mr. Angus Sinclair's work in the *Scientific American* supplement of October 3d. Through the courtesy of Col. Hain, manager of the Manhattan road, Mr. Sinclair, assisted by Mr. J. D. Campbell, general foreman of the elevated railroad machine shops, made a very thorough test of the capacity and performance of one of the standard engines on regular duty. The engine was indicated for two round trips, that is, over a run of about 34 miles, and all other necessary data taken.

The average power expended during the whole distance was 77.8 h. p., 10 per cent. of which is allowed for friction of the engine, leaving 70 h. p. net. This by actual experiment.

By theoretical determinations I get 70.3 h. p., which includes 5 per cent. friction, or a net of 67 h. p.

The difference is 3 h. p., or 4¼ per cent., which may represent the excess of weight of train actually tested.

Since these nearly similar results are obtained by totally different methods of working, comment is unnecessary.

Let us glance at a summary of the results:

For trains of 80 tons weight:

Average *tractive* power supplied per train—	
Steam	73.6 h. p.
Sprague electrical system	43.1 h. p.

For 63 trains:

Steam	4,640 h. p.
Sprague electrical system	2,715 h. p.

Total *steam* power supplied:

Steam system	4,640 h. p.
Sprague system	4,525 h. p.
Any other electrical system	7,882 h. p.
Difference in last two	2,860 h. p.

Passenger capacity of each 80-ton train:

Steam	151
Electrical	344

Passenger capacity of 63 80-ton trains:

Steam	9,513
Electrical	21,672

Weight of train for 344 passengers:

Steam	92.6 tons
Electrical	80.0 tons
Steam excess	12.6 tons

Weight of 63 trains for 344 passengers each:

Steam	5,834 tons
Electrical	5,040 tons
Steam excess	794 tons

Passengers carried by—

63 92 6-ton steam trains	21,672
Equivalent weight electrical trains	25,074
Excess with heavily loaded trains	3,402

Strains in any unit:

Steam	100
Electrical	33 to 66

Cost of coal:

Steam	$3 50
Sprague electrical	1 00

I have not thought it necessary to explain the particular methods of motor construction or regulation, or the system of generation and distribution. Let it suffice here to say that these matters have been thoroughly worked out to my satisfaction, and I anticipate no serious obstacles.

I have presented these facts about the present and future of the elevated roads of New York for your serious consideration, not because you are particularly interested in New York, but because the problem of rapid transit in Boston has become one of the urgent needs of the present. As the elevated roads in the former city met with great opposition, so has the project of reaching the suburbs of Boston aroused a host of objectors.

The reasons for this strenuous opposition are in part sound. Your streets are many of them narrow, some of them crooked. Property owners along the proposed route of a road object to a double track system of roads extending the full width of a street; to the noise, the steam, the water, the oil, the vibrations, the dirt and cinders incident to a steam system. But the elevated roads of New York were projected some years ago. Active minds of engineers and inventors have worked out improved methods of construction for the special needs of cities like Boston, where trains may be required to go by one street and return by another. Such roads can be built, the structures of which will not take up as much room in the streets, will not obstruct the air and light much over one-half as much as the New York roads, and I feel confident that they can be built for less money.

With electric propulsion you can have rapid and smooth running trains of one, two, or more car units. The strain on the structure being much less than in a steam plant, the whole structure can be made lighter in the same proportion.

Dust, smoke, cinders, oil and water will disappear.

Power will cost less.

Trains can be run at shorter intervals and under more perfect control.

The energy of the train will become available for the purpose of braking.

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Repairs of the superstructure will be less.

In short, electric propulsion, more than any other thing, will make practicable for Boston what it has so long and so sadly needed, rapid transit to its suburbs. I need hardly point out to you the increase in the value of this property, which will more than pay the cost of the roads.

CARRYING AND DISTRIBUTING ELECTRICAL CONDUCTORS THROUGH CITIES.

BY ELIAS E. RIES.

INTRODUCTORY REMARKS.

It is not often that a subject of such importance to the present and future development and growth of our large cities has received such reckless treatment and unjust criticism at the hands of the general public and the daily press, nor is it often that a question of equal prominence appears to be so little understood, not only by those who have been foremost in criticising it, but by those who claim more or less acquaintanceship with the theoretical and practical questions involved.

The need of a change in the present method of carrying and distributing electrical conductors in our large cities has long been manifest to every electrical engineer who has given the subject a moment's consideration, but how or in what manner this change was to be accomplished to the satisfaction of all the electrical companies involved without destroying the efficiency of any class of service and at the same time prevent future complications of a more serious character, is still an open question, and a problem which, apparently, has not yet been satisfactorily solved.

Among the large number of plans proposed as a solution of this difficult problem very few contain the elements most essential in a system designed to carry and distribute all classes of electrical conductors, and it is very evident that the promoters of a large majority of the conduits and underground "systems" brought to the notice of the Subway Commissioners do not even comprehend the fundamental features and requirements of the problem with which they are dealing. The uncertainty caused by the present state of affairs practically puts a stop to all further construction of overhead lines, and very materially impedes the present development and extension of electrical service in all large cities, whether affected by the underground law or not, as it is well known in electrical circles that a change such as is contemplated, and which must sooner or later be made, would render all, or a very large proportion of all the existing overhead wires comparatively worthless, since it is known they cannot be satisfactorily employed in any underground system that is likely to be adopted. A prominent telephone manager, about to increase his exchange facilities by the addition of some new aerial cables, recently told the writer that it would be worth $20,000 to his company to know just then whether or not a successful underground system would be forthcoming, and if so, how long it would be before it can be made available for practical use. This feeling of uncertainty as to the immediate future of overhead conductors is naturally the cause of considerable anxiety, more especially in telephone and electric light circles, and is principally to blame for the loose and reckless manner which has characterized, almost from the date of their introduction, the carrying and supporting of electric light and telephone wires.

Nothing is more apparent than the fact that a conduit system, in order to satisfactorily take the place of and do away with the present network of overhead wires and at the same time successfully fill the demands that will be made upon it in the near future, must not only be absolutely permanent and make ample provision for future growth, but must also be sufficiently comprehensive in its scope to meet the requirements of every class of electrical service. It is not denied, nor is there any doubt but that a successful system of this kind can be constructed, but there are a great many difficulties—electrical, engineering and financial—that must first be considered and overcome before such a system can be regarded as an accomplished fact, and it is these difficulties that we will now proceed to investigate, and endeavor to show how and in what manner they may be successfully and practically overcome.

In order that the nature of the problem before us may be fully understood, it is proposed before going into the difficulties and other obstacles that will have to be surmounted, to generally acquaint ourselves with the present methods of carrying and distributing electrical conductors, the manner in which these conductors differ from each other, the kind of service they render, and the requirements necessary to properly distribute them. We will then turn our attention to some of the technical difficulties that overhead and underground wires are subject to when carried through the city in the ordinary manner, and to a consideration of the various other obstacles that present themselves. As soon as we have sufficiently mastered the situation in its different aspects, we shall briefly review what has already been done toward effecting the desired change, and ascertain by what means the obstacles that have heretofore opposed the construction of a successful conduit system can be removed and a practical, efficient and comprehensive system devised.

CLASSIFICATION OF CONDUCTORS.

The wires and other electrical conductors in all large cities at the present time differ from each other in several important respects, as regards the nature and strength of current carried, the form of distribution required and the kind of service rendered by them. These wires will naturally exercise an important influence upon the size, shape and scope of our proposed conduit system, and, if this were all that required consideration, the construction of such a system would be simple enough. Contrary to popular belief, however, this is not all. It is just as difficult to construct a successful conduit system without taking into consideration the requirements of the various conductors that it is intended to carry and the effect upon each other and upon the conduit system of the different kinds of currents that traverse these conductors, as it is to accurately calculate an intricate astronomical problem without making allowance for the variation due to the attractive influence exerted by other bodies. Our first step, therefore, will be to determine what constitutes the requirements of the different kinds of conductors, but in order to do this properly we must first classify them. In doing so we will for the present confine ourselves to a consideration of such features only as have a direct bearing upon the construction and successful operation of the conduit system.

These electrical conductors may be classified, first, *with respect to the nature of the current carried by them*, and second, *with respect to the form of distribution required.*

For convenience in designating the different kinds of conductors, *with respect to the nature of current carried by them*, we will divide them into three general classes, as follows:

Class 1.—*Telephone conductors:* This class comprises all electric wires, cables and other conductors that carry weak or sensitive currents, such as are used on all ordinary telephone lines, in certain forms of electric time systems, and in other, and as yet comparatively undeveloped forms of electrical service, such as in telemeter and photophone circuits and in operating certain forms of regulating and synchronizing apparatus.

Class 2.—*Telegraph conductors:* This class comprises all electric wires, cables and other conductors carrying intermittent or "make and break" currents of moderate strength. To this class belong all the various telegraph wires, the fire alarm and police wires, the market quotation and stock wires, the district telegraph, call bell, time telegraph and burglar alarm wires, etc.

Class 3.—*Electric light conductors:* This class in-

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cludes all electric wires, cables and other conductors that carry high tension currents, such as are now employed in electric arc lighting, for charging secondary or storage batteries, etc. To this class may also be added for the present all other conductors designed to carry and distribute low-tension dynamo currents for incandescent lighting, for supplying power, etc., as well as other conductors or mains carrying heavy but comparatively steady currents intended to be used for district supply purposes.

In addition to the conductors mentioned in the above classes, there are other more recent applications of electricity requiring currents of a different nature, and these must not be lost sight of in devising our conduit system. Among the currents here referred to that require special provision and classification may be mentioned, when flowing in large quantity, or under a high tension or electromotive force: *alternating*, *intermittent* and *pulsatory currents*. None of these have so far been employed in practice, although the former has been proposed as a means for electric lighting by induction.[1]

As we shall subsequently see, this difference in the kind of electric current carried by the numerous conductors to be provided for will necessitate great care and judgment, if it is desired to carry them all in one conduit system, in order that the different classes of current shall not interfere with each other, and this will in a great measure determine the design and arrangement of our conduit.

REQUIREMENTS OF DISTRIBUTION.

There is, however, another feature of these conductors that requires fully as much attention and is probably of more importance to the success of a conduit system than any other single feature, and that is, the form of distribution required by different conductors.

It is well understood that one of the principal objections to overhead wires, and one that, directly and indirectly, is the cause of more annoyance and trouble than all their other faults put together, results from the entire lack of system that prevails in supporting, carrying and distributing them, and this lack of system is largely due, outside of economical considerations, to the great variety in methods of distribution that is required. Now, as it is manifestly impractical to construct an independent conduit system for each class of conductors and for every kind of distribution that these conductors may require,—as indeed such a network of conduit systems would be vastly more objectionable than the present overhead wires,—we must devise a properly organized system which shall not only be sufficiently comprehensive to serve every portion of the city with any desired class of conductors, and at the same time be so simple in its arrangement as to occupy the least possible number of streets, but it must also thoroughly accommodate itself to every possible form of distribution that may be required. Before this can be intelligently done, however, it will first be necessary to determine what forms of distribution are required.

To properly classify all the electrical conductors with respect to the form of distribution they require is a somewhat difficult matter, for the reason that such distribution depends altogether upon the nature of the service that the conductors are expected to render, and varies greatly. For instance, while the majority of the wires belonging to the several telegraph companies extend directly from their respective offices to the city limits, from which point they continue their way to other cities and towns, the conductors of the several electric lighting stations do not extend beyond the district in which their station is located; and whereas on the one hand the telegraph wires may not make a single connection on their way through the city, the electric light conductors are designed, if necessary, to make connection with every house in their district. Between these two extremes, however, there is a wide difference in the methods of carrying and distributing other conductors or even in distributing conductors of the same class, this difference depending upon the specific nature of the service, and the number and relative location of the points to be connected or served.

As an illustration of this point, we will take the telegraph conductors as an example. Although we have stated that the majority of the telegraph wires run directly to the city limits, they do not by any means take a uniform direction in doing so. There are however, aside from these, a large number of what are termed local lines, which extend between and connect the main and the several branch offices of the different telegraph companies throughout the city, and these offices are usually widely separated and located in different sections or districts. Others again, such as the market quotation and stock wires, are confined to the business section of the city, principally to brokers' offices. Then we have the district telegraph and messenger service systems, in which the city is divided into a number of districts, each containing a district station, from which stations connection is made with a number of buildings or subscribers in their several districts. In addition to this we have the police and fire alarm wires, which with their numerous stations are scattered promiscuously throughout the entire city, the private telegraph and burglar alarm wires, wires for the transmission and correction of time, etc., each of which will require special treatment as regards distribution.

Now, while a single telegraph wire may, and very frequently does, connect with a dozen or more stations in different portions of a city, and is capable of being successfully operated when so connected, a *telephone* circuit is not adapted, when used in connection with the present system of central telephone exchanges, to be satisfactorily employed for more than one instrument or subscriber, although it may be remarked in passing that experiments have been and are still being made by which it is expected this diffculty will soon be remedied. Until this is done, however, a separate wire will be required for each subscriber if satisfactory service is desired, and it is mainly owing to this fact and to the numerous connections made necessary between the central station and subscribers either in the immediate vicinity or anywhere from a few blocks to a mile or more away, that the introduction of the telephone has so rapidly increased, in fact, nearly quadrupled, the number of aerial conductors. While a very large proportion of the telephone wires connect with the different exchanges and radiate therefrom to all parts of the city (either in the form of individual wires or cables, the latter being now preferably employed), there are quite a number of private lines, which, as far as the method of distribution is concerned, do not materially differ from some of the local telegraph wires, and like them, owing to the peculiarly scattered location of the several points to be connected, are made to take a very erratic course, and a conduit system must be very complete indeed if it can take care of and properly distribute this numerous and troublesome class of conductors, whose present overhead ramifications extend to every nook and corner of the city, and carry them in such a manner that each individual conductor, no matter how many connections it may have, will be conveyed with the least possible deviation from the shortest and most direct route that could be selected.

With respect to the distribution of conductors for electric light and power, this at the present time is still in its infancy, but in view of the great variety of conductors and systems of distribution already proposed, and to a limited extent carried out in practice, the indications are that this application of electricity will demand a greater diversity in methods of distribution than any other class of electrical service. In addition to the conductors already mentioned, it must be remembered that there are others, as yet practically undeveloped, that will make their appearance in the near future, which it is reasonable to presume will require a different kind of distribution. In fact, we have

1. ELECTRICIAN AND ELECTRICAL ENGINEER, July 1885, p. 252.

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seen that each of the three general classes of conductors—telephone, telegraph and electric light—has, aside from local influences, a distinctive feature of its own in the matter of distribution. The telephone conductors are governed in this respect by the interchangeable nature of the service and the requirements of the central office classification. The telegraph conductors, as a class, are practically unlimited as to the direction, location and number of connections they may make, while the distribution of electric light conductors, especially those intended for district supply purposes, such as the multiple arc or incandescent systems, are entirely governed by questions of potential or strength of current.

It will thus be seen that, aside from the question of properly carrying all these conductors in such a manner that they will not interfere with each other, a question, by the way, which we shall soon take up for consideration, the problem of how to provide for satisfactorily distributing these conductors, whose requirements in this respect differ so greatly, so that it will not be necessary to tear up the streets whenever a new connection is to be made, or when repairs, alterations or additions are required in any part of the conduit system, becomes a rather difficult and complicated one, but one which, as we shall subsequently see, is capable of being solved in a simple and satisfactory manner.

(*To be continued.*)

SIZE OF ELECTRICAL CONDUCTORS.

BY CARL HERING.

There are a large number of rules given in text-books, and used by manufacturers, regarding the proper size of electrical conductors to prevent dangerous heating, some of which differ so widely from each other that the engineer is often in doubt which to use in different cases, unless he has made experiments of his own to determine it empirically.

In the following article the writer has made a compilation of some of the rules given by different authors, together with others gained by practical experience, and has tried to reduce them all to such a form that they may be better compared with each other, thus enabling the engineer to select the one best suited for his purpose.

It is evident that no one rule will apply in all cases; for instance, in a naked wire hanging in the open air, a very large current per square inch of cross section, can be passed through it, if the heating is the only thing to guard against, as in a rheostat. On the other hand for a shunt magnet of large dimensions, with fine wire, or in an underground conductor surrounded with a thick mass of a poor conductor of heat, a much smaller current per square inch must be used; while if the loss of potential is the principal thing to take into consideration, as in conveying power currents, or in electric light leads, neither of the rules which would be applied in the above two cases could be used. Again, where the tenacity of the wire is the principal object, as in aerial lines, still another rule has to be used.

If a current is passed through a wire, there is a certain amount of heat produced, which will continue to accumulate as long as the current passes, and would ultimately melt the wire, unless the heat is carried off in some way. The only way in which this heat is dissipated is either by radiation, convection, or conduction, of which the first two are the most important.

If the current is C and the resistance of the whole wire is R, the heat generated continually is $C^2 R$ expressed in volt-ampères. Assuming a naked wire of any cross section, the amount of heat dissipated by radiation and convection is directly proportional to the surface exposed, for the greater the surface the greater the contact with the air. It is furthermore directly proportional to the difference between the temperature of the wire after heating, and the temperature of the surrounding air. It is, therefore, equal to the product of these two quantities. The heat dissipated by conduction through the long wire is so small that it may be neglected.

Letting Q be the quantity of heat dissipated,
θ the maximum temperature of the wire when heated by the current,
t the temperature of the air.
S the surface of the wire,
h a constant depending upon the material, the nature of the surroundings of the wire, and the units used, then

$$Q = h\ (\theta - t)\ S$$

As the heat is produced continually, and as the dissipation of heat increases with an increase of temperature, it is evident that in every case, except when the wire melts, there will be a certain maximum temperature reached, above which it will not rise; this is evidently when the heat dissipated is equal to that which is produced. If these two quantities of heat $C^2 R$ and $h\,(\theta - t)\,S$ be placed equal to each other, the value of $(\theta - t)$ will evidently be the rise in temperature and θ the maximum temperature to which the wire will be raised.

To equate these they have to be reduced to the same units. As 746 volt-ampères are equivalent to 1 h. p., if we divide $C^2 R$ by 746 it will give the number of horsepower; multiplying this by 33,000 gives the foot pounds per minute; dividing this by 60 gives the foot pounds per second; furthermore, dividing this by 772 (Joule's equivalent), it will give the number of pound-Fahr. heat units generated per second.[1]

$$\frac{C^2 R \times 33{,}000}{746 \times 60 \times 772} = C^2 R \times .000955$$

Letting θ and t be represented in Fahrenheit degrees and S in square millimetres, then we may place the expression for the heat dissipated equal to that for the heat produced. Thus

$$h\ (\theta - t)\ S = C^2 R\ .000955$$

or letting T represent the increase in temperature in Fahrenheit degrees,

$$T = (\theta - t) = .000955 \frac{C^2 R}{S h}$$

The resistance R, of the wire is

$$R = \frac{l m}{a}$$

in which l is the length in metres, a the cross section in square millimetres, and m the specific resistance—that is, the resistance of a wire of one square millimetre cross section and one metre long.

The external surface S of the wire in square millimetres is equal to the periphery p, of the wire in millimetres, multiplied by the length l in metres and multiplied by 1,000. Therefore,

$$S = p\ l\ 1{,}000$$

Substituting these values for S and R in the above equation and reducing, gives

$$T = \frac{.00955}{10{,}000} \frac{C^2 m}{a p h}.$$

This also shows that the temperature is independent of the length of the wire.

This expression gives the value of the maximum increase in temperature of a wire or strip of all materials and cross sections, provided we know the value of h. As this constant depends upon the material of the wire and on the nature of the surroundings, it will have a somewhat different value under different circumstances, but for the same material and similar surroundings of the wire the value of h will be approximately the same for a different current, cross section, shape, or specific resistance; that is, it

1. See Electrician and Electrical Engineer, April, 1883, p. 104, for direct equivalents.

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is only necessary to determine h once, for wire under certain circumstances, then for any other size or shaped wire or any other current under similar circumstances, that value of h will remain approximately the same. To determine it, pass a current through the wire and measure the increase in temperature after it has become a maximum; substitute the values of the different quantities for that particular case in the above equation and solve for h.

If the wire has a circular cross section, the formula is reduced as follows, by replacing a and p by their values and reducing,

$$T = \frac{.00387}{10,000} \frac{C^2 m}{d^3 h}$$

in which d is the diameter in millimetres.

From this equation it will be seen upon finding the value of d from it, that for the same allowable increase of temperature, the diameter has to vary as $\sqrt[3]{C^2}$; that is, if the current is increased n times, the diameter must be increased $\sqrt[3]{n^2}$ times (or the cross section $\sqrt[3]{n^4}$ times) in order that the wire may rise to the same temperature. If, for example, the current be made two times as large, the diameter will have to be made $\sqrt[3]{4} = 1.6$ times as large.

The value of h used in a certain table calculated by Sabine, when properly reduced to the units of our formula and combined with the constant, would make it

$$T = 81 \frac{C^2 m}{d^3}$$

but this table is well known to give too high results.

That given by Prof. George Forbes, when reduced to the proper units, gives

$$T = 105 \frac{C^2 m}{d^3}$$

which also gives too high results.

That used by the expert judges in the Munich and Vienna electric exhibition tests, when reduced to the proper units, gives

$$T = 66.4 \frac{C^2 m}{d^3}$$

which by certain experiments made since was also found to be too high.

Certain rough experiments made by the writer give

$$T = 33.6 \frac{C^2 m}{d^3}$$

which from the nature of the experiments probably gives a value a little too low. The test was made with a naked vertical wire.

This shows that there is a great discrepancy in the values of that constant, and that it would be rendering a great service to the profession if some one would make a series of proper experiments to determine it.

Until some reliable experiments are made and published we would suggest as rough values the following:

For a naked wire suspended in the air,

$$T = 40 \frac{C^2 m}{d^3} = .0024 \frac{C^2 m}{D^3}$$

for armatures

$$T = 50 \frac{C^2 m}{d^3} = .0030 \frac{C^2 m}{D^3}$$

and for large machine magnet coils,

$$T \quad 60 \frac{C^2 m}{d^3} = .0037 \frac{C^2 m}{D^3}$$

in which d is the diameter in millimetres and D that in inches.

The value of m should be the specific resistance for the maximum temperature, but as that would involve extra calculations, and as the formulæ are only rough values, it will answer to take the specific resistance at about 100° Fahr. and introduce it directly into the formulæ.

Assuming a mean value of .0162* as the specific resistance of ordinary good commercial copper at 0° C, correcting for temperature and introducing into the formulæ gives, for naked wire

$$T = .74 \frac{C^2}{d^3} = \frac{.045}{1,000} \frac{C^2}{D^3}$$

for armatures

$$T = .93 \frac{C^2}{d^3} = \frac{.056}{1,000} \frac{C^2}{D^3}$$

for magnets

$$T = 1.11 \frac{C^2}{d^3} = \frac{.068}{1,000} \frac{C^2}{D^3}$$

in which

T is the increase in temperature in Fah. deg.
C the current in ampères
d the diameter in millimetres
D the diameter in inches.

There are certain "rules of thumb" used in shops, and others taken from different authorities, which give for special cases the allowable "density of currents," or in other words the number of ampères of current which should be used per area of cross section. But it is evident from what was said above regarding the heating, that such rules will apply only to a limited range of sizes, for, as stated above, if the current is doubled, for instance, the cross section must be more than doubled (or more accurately $n^{\frac{4}{3}}$, if n is the number of times the current is increased) in order that the heating should be the same.

Some of these rules are as follows:

For armatures with thick wires use 3 ampères per square millimetre; this equals 1,935 ampères per square inch. For thin wires 4 ampères per square millimetre, which equals 2,580 ampères per square inch.

For machine magnets with thick wire 1.5 amp. per sq. m.m, or 968 amp. per sq. inch. For thin wire 2 amp. per sq. m.m. or 1,290 per sq. inch.

Another authority gives: for armatures with thick wires, 2 amp. per sq. m.m. (or 1,290 amp. per sq. in.). For thin wires 3 amp. per sq. m.m. (or 1935 amp. per sq. inch.). For magnets with thick or thin wire 1.5 amp. per sq. m.m. (or 968 amp. per sq. in.).

In certain Gramme machines the following was found to have been used:

For armatures 2.4 to 6 amp. per sq. m.m. (or 1,550 to 3,870 amp. per sq. inch).

For magnets 2 to 7.3 amp. per sq. m.m. (or 1,290 to 4,900 amp. per sq. inch).

Sir William Thomson's rule is: 50 amp. per square centimetre, which equals .5 per sq. m.m. or 322 per sq. inch.

An English rule for leads is: 1,000 ampères per square inch, which equals 1.55 per sq. m.m.

From some experiments made by Messrs. Clarke, Forde & Tayler, for the Indian & Oriental Electrical Storage & Works Co., published in the London *Electrician*, for April, 1883, the general conclusion arrived at is, that up to 10 ampères, it is safe to allow one ampère per 10 pounds of copper per mile, either naked wire or with insulated wires buried in sand in the hot Indian climate. This, when reduced to current per square inch will be found to be about 2,030 ampères per square inch.

Edison is said to use 2 to 3 ampères per square millimetre (or 1290 to 1935 amp. per sq. inch) in his underground leads.

A firm in Germany uses as a maximum for incandescent light leads, 3 amp. per sq. m.m. (or 1,935 amp. per square inch).

* See ELECTRICIAN AND ELECTRICAL ENGINEER, p. 459, Dec. 1885.

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For galvanized iron wire for rheostats, the writer found 20 to 21 amp. per sq. m.m. (or about 13,000 amp. per square inch) for small wires, to be the greatest which it would stand without oxidizing.

For thin, soft iron wire, about 29—30 amp. per sq. m.m. (or 19,000 amp. per sq. inch) was required to maintain it at a red heat.

Thin plates used for rheostats will stand about 2 to 4 times the current that a wire of equal cross section will.

For lead safety fuses made of 60 per cent. lead and 40 per cent. tin, the following table giving approximate values, may be used. They give the current in ampères which will melt the wire.

AMERICAN GAUGE NUMBER.	AMPERES.
24	4.6
20	9.0
18	12.8
16	18.
14	24–26
12	32–38
10	48–56
9	62–70
8	88–96

One half of that given in the table is used in calculating the fuses for incandescent lighting, so that double the normal current will melt them.

Although all the above rules for the density of the current differ from each other, yet as they have been and are still used in practice, they will enable one to make a fair selection for special cases which will not be very incorrect, provided the density of the current is decreased for an increase of the size of the wire, as stated above.

For one ampère per square millimetre, and for 1,000 ampères per square inch, the following table gives the currents allowable for the different sizes of the American or B. & S. wire gauge. For any other density of current the currents can readily be determined from the table by mere multiplication:

AMERICAN GAUGE NUMBER.	CURRENT IN AMPERES. At 1,000 amp. per sq. in.	CURRENT IN AMPERES. At 1 amp. per sq. m.m.	AMERICAN GAUGE NUMBER.	CURRENT IN AMPERES. At 1,000 amp. per sq. in.	CURRENT IN AMPERES. At 1 amp. per sq. m.m.
0000	166	107	19	.98	.64
000	132	85.2	20	.80	.52
00	105	67.7	21	.64	.41
0	82.9	53.4	22	.50	.33
1	65.7	42.4	23	.40	.26
2	52.1	33.6	24	.32	.21
3	41.3	26.8	25	.25	.16
4	32.8	21.2	26	.20	.13
5	26.0	16.8	27	.16	.10
6	20.6	13.3	28	.13	.08
7	16.3	10.5	29	.10	.06
8	13.0	8.39	30	.08	.05
9	10.3	6.65	31	.06	.04
10	8.15	5.25	32	.05	.03
11	6.47	4.17	33	.04	.03
12	5.13	3.31	34	.03	.02
13	4.07	2.62	35	.02	.02
14	3.15	2.08	36	.02	.01
15	2.56	1.65	37	.02	.01
16	2.03	1.31	38	.01	.01
17	1.61	1.04	39	.01	.01
18	1.28	.83	40	.01	.01

For incandescent lighting only the leads to lamps near the machine should be calculated for heating, those leading to lamps at a greater distance should be calculated for an allowable loss of potential, as the wires must be much larger for distant lamps than if they were calculated so as not to heat.

If L is the distance (that is, half the length of the wire) in feet, from the machine to the lamps, the following formula, for good commercial copper, at about 60° F. can readily be deduced :

$$A = \frac{.01566}{1000} \frac{C\,L}{V}$$

in which A is the cross section in square inches, C the current in ampères, and V the allowable loss of potential in the leads. For lamps at a distance this will be found to give a larger size wire than if it were calculated not to heat, and should therefore always be used in such cases.

If a is the current required per lamp and n the number of lamps supplied by that wire, the value becomes,

$$A = \frac{.01566}{1000} \frac{n\,a\,L}{V}$$

Or if d is the diameter in mils

$$d = \sqrt{\frac{20\,n\,a\,L}{V}}$$

For 3 volts loss of potential these values become,

$$A = \frac{.00522}{1000}\, n\,a\,L$$

$$d = 2.58 \sqrt{n\ a\ L}$$

There have been a number of formulæ calculated, giving the diameter of the wire which will be the most economical, taking into account the cost of the power lost in the wire and the cost of the wire itself. They are, however, based upon the assumption that naked wire is used, and therefore cannot be directly applied in practice, as the cost of a pound of insulated wire, such as is used for lamps, is much more than a pound of naked wire. Furthermore, a pound of insulated wire has a different resistance than a pound of naked wire of either the same diameter or the same length. The current per square inch is in these calculations found to be smaller than that generally used in practice, which is explained by the above statement. It is therefore quite safe to take a somewhat higher current per square inch than such formulæ would give.

Sir William Thomson found, by taking into account the cost of power lost and the price of naked wire, that 50 ampères per square centimetre (or .5 ampères per sq. m.m., or 322 ampères per sq. inch) is the most economical. This may, from what was said above, be safely taken somewhat higher.

Prof. George Forbes gives a formula for calculating the heating of a coil of a machine magnet, from the amount of the outside surface of the coil, exposed to the air. This formula is as follows:

$$C = 0.25 \sqrt{\frac{s}{R}}$$

in which,

C is the current in ampères necessary to raise the temperature of the coil 50° C. (or 90° F.).

s is the radiating surface in square centimetres; that is, the length of the coil multiplied by its periphery.

R is the resistance in ohms at 50° C. (or 90° F.)

If S is the surface in square inches, his formula becomes,

$$C = 0.64 \sqrt{\frac{S}{R}}$$

There have been some calculations or statements made that insulated wire will cool more rapidly than naked, for the reason that the surface of the insulation exposed to the air is greater than that of the naked wire. This would no doubt be the case if the insulation conducted the heat through it readily. A good insulator is, however, generally a poor conductor of heat. The correctness of the above statement, therefore, no doubt depends upon the nature of the insulation; for instance, in the Edison underground cables the heat is no doubt led off more slowly than if the wires were in the open air, as they are entirely

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surrounded by a poor conductor of heat. Again, if the above statement were correct, it would seem absurd to cover steam pipes with a heat-insulating material, as they would in that case cool off more rapidly; good engineering practice has, however, shown that they cool less rapidly when covered than when naked.

ON TESTS AND EFFICIENCIES OF DYNAMO ELECTRIC MACHINES.

BY CHARLES F. HEINRICHS.

SOME years ago, during the opening of our present electrical industry, every inventor could state unchallenged, that his dynamo was the best, for the reason that no exact knowledge existed of the form of armature or dynamo which would give the highest results. That time has passed, and out of the labyrinth of opinions expressed by learned professors, and empirical theories found by advanced inventors, we have come to the stage at which practical tests of the efficiency of the dynamo are the proof of its best principles of construction.

Considerable time and energy has been expended in reaching this point, but it is still necessary to clear away much of the confusion which has up to the present time surrounded the practical testing of dynamos, and electrical engineering generally. Most promising reports still appear of some new dynamo, or incandescent lamp, allowing 30 lamps of 30 c. p. each to be worked with an expenditure of two h. p., but are not supported by any tests substantiating such results. It would be unfair to judge adversely of every new invention, the merits of which are not at once apparent; on the other hand fictitious figures which are not derived from trustworthy tests ought neither to be countenanced nor given publicity, to the injury of other honest competitors.

One electrical exhibition after another brings forth the same dynamos and lamps followed by published tests of the efficiencies of the dynamos nearly every month, although upon comparing the many reports published during the last five years, it appears that, with few exceptions, most of the results do not agree with each other. Most experimenters found their own formulæ for expressing the electrical or commercial efficiency of the dynamos, and have given in their reports few data in support of the results shown, therefore no one can effectually check the latter, accept the same as correct, or gain any knowledge for guidance in future tests. Repeatedly, two final results, obtained by two different methods are given, from which to choose the right one. All such reports of tests have only added to the general confusion and distrust existing on this subject and ought not to be further countenanced.

Every person, however high his scientific standing may be, is responsible for the correctness of the results found by him. The objects of scientific experiments and research are not merely to record them in scientific annals, but to serve commercial pursuits.

The object of the following propositions and considerations, given under the several headings, is to demand of every experimenter that he furnish with each report of tests, complete data as specified below, in order that the efficiencies found may stand supported by the latter.

The settlement upon some simple and reliable mode of testing, though very desirable, can not yet be enforced and may well be left to the ingenuity of every experimenter; but under no condition, ought two results of the same efficiency obtained by different methods to be accepted. The experimenter is bound to obtain the true efficiency and if he has employed two or more methods all must very nearly agree with each other, or the experimenter must find out the true one and explain why the other results are incorrect. Such information will be valuable and serve in future tests.

1. MEASUREMENTS OF THE ELECTRICAL ENERGY.

Very little can be said in regard to the measurements of the electrical energy which have in most published reports been shown to be very accurate. Whenever the values of the current, E. M. F., and the resistance agree with Ohm's law, they must be accepted as correct. On the other hand it is most certain that the three values measured will never agree exactly as far as the third place of decimals, and although the experimenter may *square* the results for his further calculations, he ought to give the figures as observed. Whenever the figures are given *squared* no one can tell to what an amount it has been done. Thus exactly agreeing data of C, E. M. F. and R. may be distrusted. Further, there should always be some tests made, having a directly measurable resistance in the external circuit, so that all three values may be measured separately, and not as in the case of lamp circuits where the resistance must be calculated from C, and E. M. F.

The following data are required :—

Description of the electrical measuring apparatus or methods employed.
Data of calibration of above.
Resistance of dynamo at the commencement and finish of tests.
" of armature as above.
" of field magnets as above.
" of external circuit, warm.
Current, total; and if a shunt-wound or other combination dynamo, the current in each branch must also be measured and given.
E. M. F., at terminals of dynamo and total.
Electrical energy; total.
" of external circuit.
" of internal circuit.

2. HORSE-POWER MEASUREMENTS.

However exact all measurements of the electrical energy may have been made, should the horse-power measurements appear improbable and untrue, in such case the calculations of the efficiencies given to the dynamo must also be untrue. All horse-power values obtained from indicator diagrams are only approximate, are liable to great variations from the truth, and no exact values of the power absorbed by the friction of the engine and armature can be got without additional instruments. Thus in the report of some tests recently made "far west," as much as 17 per cent of the total horse-power indicated had been put down to the friction of the engine, and only 1.16 h. p. was left unaccounted for. In case the friction of the *two armatures*, the weight of one was probably 600 pounds, absorbed *only* 1.16 h. p., the electrical efficiency of the dynamos would be 100 *per cent.* This example shows to what results rough and ready tests may lead.

To obtain reliable values of the horse-power absorbed a transmission dynamometer must always be interposed between the dynamo and the prime mover, which will indicate the power absorbed by the dynamo. Experience has proved that no calculations of the power, should be made from the indications of any dynamometer, but the indications should be calibrated for every different test, which can best be done with an absorbtion dynamometer, by which the value of the indications of the transmission dynamometer can be determined in foot pounds.

The simplest form of the absorbtion dynamometer is the Prony brake. Little has been published to show under what conditions the results obtained with this apparatus could be relied upon. During the tests of the writer's dynamo,[1] sufficient experiments were made to prove that a certain size of brake will perform effectively for a limited range of values only. Many experimenters have advised using frictional surfaces as large as possible; this has been found to give the most untrue results. Mr. W. H. Maw, M. I. C. E., when looking over the data obtained during the tests of the writer's dynamo, found the results to agree with a constant deduced from a great number of experiments made by Mr. Maw during the last 21 years, viz :

$$\frac{v.\ a.}{H.\ P.} = 700.$$

1. See *James Dredge Electric Illumination*, vol. ii.

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v = velocity of the brake pulley in feet per minute.
a = width of the brake lever in inches.

The quotient 700 expresses the maximum unit of surface between the brake pulley and the jaws of the lever, under which reliable results can be obtained. Thus the diameter of the brake pulley and the width of the lever ought to be given with the usual Prony brake data. The most simple transmission dynamometer is the Royal Agricultural Society dynamometer.[2] Like the Morin dynamometer it has only two pulleys, one for receiving and the other for transmitting the power. The latter pulley is fixed to the shaft, thus the machine to be tested may also be connected up directly to the dynamometer without a belt. Both pulleys are connected with each other by flat curved springs, which are so arranged that the angular displacement of the receiving pulley in relation to the transmitting pulley may be proportional to the power absorbed. The flat springs are exchangeable, thus if comparatively stiff springs were used during the measurements of the electrical energy of say 100 h. p., very elastic and feeble springs may afterwards be used to measure the small horse-power (of say 1 to 3 h. p.) absorbed by the friction of the armature. The apparatus which indicates the amount of power transmitted may be made very light and will have no influence whatever upon the indications; unlike the Morin dynamometer, in which the centrifugal force of those parts, at high speed, change the value of the indications. There can be no doubt that the Agricultural Dynamometer in conjunction with a Prony brake of proper size, will give the most reliable results. Two results of the same test, one obtained with a transmission dynamometer and other with an absorbtion dynamometer, differing several per cent. from each other, ought not to be accepted. If both results do not agree the experimenter must continue his work until he obtains the true result and finds out the reason why one of them is incorrect. Every armature which is in ordinary use connected with a belt to the prime mover, must be connected in the same manner to the transmission dynamometer during the tests, otherwise an enhanced commercial efficiency will be obtained; since the friction of the armature is less when directly connected to the shaft of the dynamometer. On the other hand a second set of tests may be made to show the saving of power if connected directly to the dynamometer.

The following data are required :

Number of revolutions of armature.
Weight of armature.
Diameter of bearings.
" of commutator.
Pressure of brushes upon commutator.

TRANSMISSION DYNAMOMETER.

Number of revolutions of dynamometer.
Indication when loaded.
" " driving dynamo empty.
" " running empty.

Data of calibration of transmission dynamometer for each test, or

PRONY BRAKE.

Number of revolutions of brake pulley.
Weight on scale.
Length of brake lever.
Width of " "
Diameter of brake pulley.

Total power applied.
Power absorbed by friction of armature.

3. EFFICIENCIES OF DYNAMO.

As stated above, most experimenters have found their own formulæ for expressing the electrical and commercial efficiency. No reason can be given explaining the fact since the following formulæ are well known :—

I.

$$\frac{\text{Total electrical energy}}{(\text{Total power applied}) - (\text{power absorbed by friction of armature})} = \%$$

This formula expresses the true electrical efficiency of the dynamo.

II.

$$\frac{\text{Total electrical energy}}{\text{Total power applied}} = \%$$

This formula has been used erroneously by many experimenters to express the electrical efficiency.

III.

$$\frac{\text{Electrical energy appearing in external circuit}}{\text{Total electrical energy}} = \%$$

This formula gives the ratio of the total electrical energy appearing in the external circuit; thus showing the usefulness of the electrical system and may be called the useful efficiency of the dynamo.

IV.

$$\frac{\text{Electrical energy appearing in external circuit}}{(\text{Total power applied}) - (\text{power absorbed by friction of armature})} = \%$$

This formula has been used erroneously by many experimenters to express the commercial efficiency of the dynamo.

V.

$$\frac{\text{Electrical energy appearing in external circuit}}{\text{Total power applied}} = \%$$

This formula expresses the true commercial efficiency, *i. e.*, the ratio of the total power given to the dynamo by the prime mover appearing in the external circuit.

Of the five formulæ only the first, third and fifth are required and should be given in every report, expressing the following efficiencies :—

Electrical efficiency.
Useful "
Commercial "

Several tests but with different loads ought to be made to show with which load the highest efficiencies and figures of merits can be obtained.

4. FIGURES SHOWING MERITS OF DYNAMOS.

However high percentages of efficiencies may be shown by a certain dynamo, the *total* efficiency has not thus far been shown, since the tests may have been taken under conditions which can not be got during ordinary and continued use. A recent report of tests contains the following statement: "*The second set* (of tests) *made some days later on, showed that the machine had not been sufficiently cooled from the first set of measurements.*" This shows conclusively that that dynamo cannot be called an efficient one, since the accumulation of heat must be very great, and will destroy any insulation within a short time, or the dynamo is used in practice very much under the capacity as tested.

Endurance tests and exact thermometer measurements will bring these points well out.

Many comparisons have been made between the total weight of the dynamo and the electrical energy given out by the latter. Such comparison, if encouraged, will lead to dynamos with light frames and insecure base plates. The weights to be known are those of the iron and copper of the armature and field magnets. The latter data will convey scientific information, and comparison between them and the electrical energy would be useful and instructive. Thus the dynamo which gives, with the least iron and copper, the highest efficiency and maintains a low temperature, will have the highest figures of merit. The base plates ought, in the interest of the user, to be made as strong as possible.

The following data are required :

Weight of iron of armature.
Weight of copper of armature.
Weight of iron of field magnets.
Weight of copper of field magnets.
Exact temperature of armature and field magnets on commencement and finish of tests—say of 5 to 10 hours' duration, without stoppage.

2. See *James Dredge Electric Illumination*, vol. ii, page 227.

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5. CLASSIFICATION OF DYNAMOS.

The different dynamos ought to be divided into classes, and whenever the efficiency of a dynamo or its figures of merits are stated, the class to which the dynamo belongs ought also be named.

The following classes may be adopted:

Class A—Series wound dynamo, with constant current of moderate quantity and high E. M. F.
Class B—Shunt wound dynamo, with constant E. M. F. and large current.
Class C—Dynamos requiring special exciter.
Class D—Dynamos with alternating currents.
Etc., etc.

Whenever the efficiency or figures of merits of a dynamo are given, the class to which it belongs ought also be named. Thus the useful efficiency of a dynamo of Class A can never be as large as that of a dynamo of Class B, and it would be misleading to compare the two with each other. No exact rules seem to have been followed up to the present time by juries of electrical exhibitions to guide their decisions when granting awards. In some cases no tests whatever have been taken, whilst the few incomplete tests taken during a few exhibitions have produced no conclusive and reliable results.

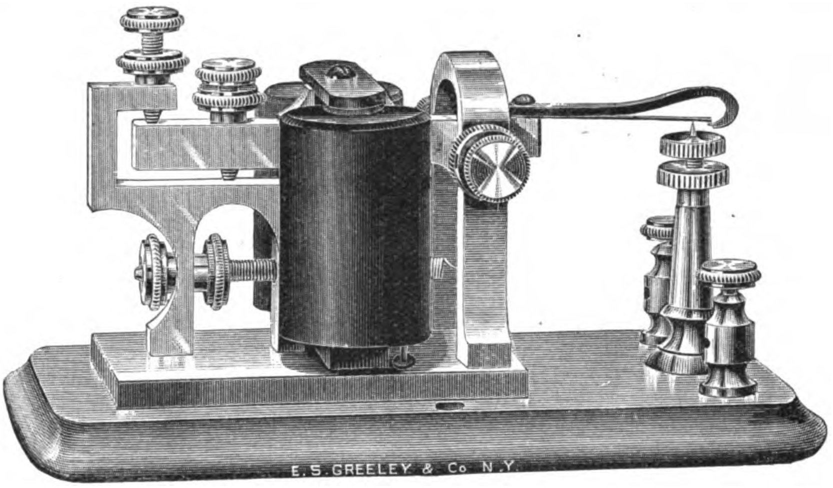
Some time ago the jury of an electrical exhibition granted a first prize to a dynamo of Class A which requires more copper on the armature, to develop a given electrical energy, than any other of the same class. The accumulation of heat is also great in the armature of the same machine and no tests had been taken, thus the award could not well be explained. Upon inquiry it turned out that the jury had been guided by the fact that very effective current-regulating devices were attached to the dynamo and on account of the latter they had made the award. Such a decision is a bad precedent which ought not to be followed. Exhaustive tests, proving the high efficiencies and merits of the dynamo, should be the only guide to the granting of the awards. Every award should contain all the data specified above, also the efficiencies and figures of merits of all other competing dynamos of the same class, and the degree of the *total* merits found should decide the degree of the award to be given.

The above subject ought to receive the attention of the whole profession, and others may still have to add valuable data. Untrue and deficient tests serve no one except the dishonest, and should no longer be countenanced by the electrical press. Doubtful and incomplete reports of tests ought not to be published at all.

ECONOMY IN LOCAL BATTERIES.

THERE are in daily use on the Morse telegraph lines of the United States, not less than 30,000 local sounders, and it is not unlikely that the actual number, if complete statistics could be obtained, would fall but little if any short of 50,000. Assuming the first mentioned number as a basis, and assuming that each sounder consumes in its local battery 25 pounds of sulphate of copper (by no means a very extravagant allowance), the total consumption of sulphate of copper amounts to no less than 750,000 pounds per annum, amounting, at five cents a pound, to $37,500. The corresponding consumption of zinc would be about 100,000 pounds, which, at say three cents a pound, would amount to $6,000. Making a fair allowance for incidental expenses, such as the cost of distribution, for example, the total value of the material consumed cannot fall short of $50,000, and is probably much more than this.

It is at once apparent from these figures that a simple appliance, adding but a trifle to the cost of each instrument, which will effect a material saving in the cost of local battery maintenance, is well worth the attention of telegraphic managers. An instrument recently introduced, called the "economic" sounder, seems to fulfill these requirements in a convenient and efficient manner. The electro-magnet of the sounder is wound with two coils which are connected in multiple arc. One of these has the same length and resistance as that of the ordinary sounder, while the other is composed of a thin wire of high resistance, say 100 ohms or more. A contact-spring is placed on the lever of the sounder, and is so connected that when the armature has almost completed its closing stroke, the circuit of the thick wire coil is interrupted, thus confining the current to the thin wire coil of high resistance. The magnetism produced under these conditions, although comparatively weak, is nevertheless quite sufficient to hold the armature in place. The principle of the instrument, therefore, is, that the armature is drawn down by a strong current and retained in place by a weak one. Under these conditions, the sounder not only works more freely, but an important saving is effected in the consumption of material, a saving which, from theoretical considerations, we should estimate to be not less than 50 to 75 per cent. If the invention should come into general use, it will at once



THE ECONOMIC SOUNDER.

be seen that this would amount to a tidy little sum in the aggregate.

The accompanying illustration will give a good idea of this improved sounder as manufactured by E. S. Greeley & Co., of this city.

THE PRODUCTION OF GUTTA-PERCHA.

THE industry of gutta-percha production is likely to be greatly increased by the discovery of Dr. Edward Heckel. Dr. Heckel says there is a tree in Central Africa, Butyrospermum Parkii, called by the natives "karite," or "care," which is likely to replace the gutta tree. The berries of this tree produce a stearic wax, called "butter of karite," and valued highly by the natives and travelers. The tree covers the vast tropical area of Central Africa in dense forests, and after it has attained the age of four years, it is possible by discreet incision to obtain from its trunk and larger branches an annual supply of four kilograms of gutta ($5 to $6 per year at the present price) without injuring the tree in the least. By reason of the great facility with which this tree grows in all kinds of soil, and because of the success attending its cultivation in a few places, Dr. Heckel thinks it can be profitably transplanted into the English and French colonies. Guided by botanical analogy, he also suggests it as highly probable that the Indian species of Bassia will give a product similar to that of the karite of Africa.

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SUBTERRANEAN SYSTEM OF THE STANDARD UNDERGROUND CABLE CO.

In order to thoroughly meet the conditions essential to a general subterranean system for large cities, the Standard Underground Cable Co. has devised a comprehensive plan in which all minor details have been so carefully elaborated, that it deserves the thorough consideration of those interested in this class of work.

The permanent character of the Waring cable, its high insulation, and perfect mechanical qualities, are now very generally recognized in electrical circles. Wherever used it has never failed to give entire satisfaction, and it is for the purpose of providing for its adoption in all branches of electrical service, that a plan of distribution has been prepared especially designed for the accommodation of various classes of conductors. Many electrical engineers are of the opinion that in subterranean work provision should be made for the drawing in and out of cables, in order to thoroughly provide against their total loss in case of injury, while necessary changes can be readily made without disturbing the surface of the street. A noticeable feature of this system is that the permanent character of these cables, permit of the general utilization of surface conduits, which include not only those whose lids are level with the surface of the pavement or flagging, but also any which may be located just below it, the general idea being to place them above all other systems of underground service. By this plan the annoyance arising from the opening of streets is reduced to a minimum, while should repairs be necessary, they can be readily made. Past experience, however, has demonstrated that protected in this manner from mechanical injury, the Waring cables do not require repairs after being properly placed in position. In order to provide for the various requirements of city work, and to overcome the obstacles which will necessarily be encountered, several methods of distribution are shown, which it is believed will fully provide for all probable emergencies.

The proposed location of conduits is shown in figure 1, also the connection and test boxes, and provisions for leading from roofs, vaults and poles. Beginning at the right of the diagram, is a street conduit, consisting of a rectangular cast-iron box, with adjustable covers which in this case is supposed to be sunk in a trench two feet deep. The height of this trough being one foot outside, its top is but one foot below the street surface, above the lines of water and gas pipes, thus avoiding contact with them. It may be placed even nearer the surface. It is of course subject to the action of the frost, which is fatal to many proposed systems but the different sections of this conduit are not rigidly secured together, and it is not proposed to make it either water or air tight. The yielding nature of the lead covered cables will permit their accommodating themselves to any irregularity arising from a disturbance of the conduit by frost.

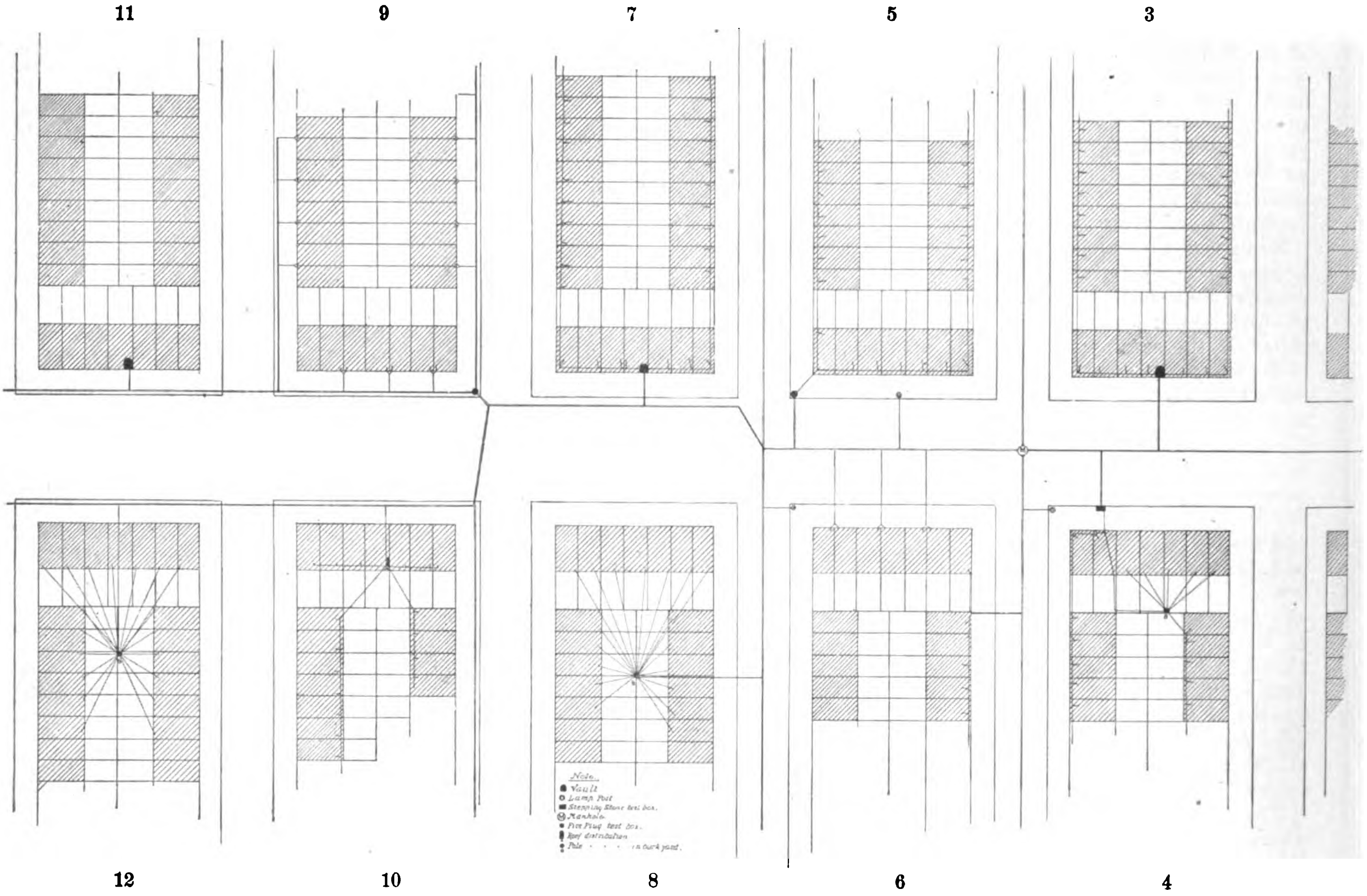

FIGURE 1.

Beginning about the centre of the cut as shown, the conduit deflects to one side of the street, nearer the sidewalk, and then passes to the curb on both sides, where it takes the sidewalk surface conduit just inside the curb-line. In this plan, four different positions of one line of cable are shown, any of which may be adopted according to the nature of the obstacles encountered which may necessitate a divergence from what might otherwise be the most feasible route. Ordinarily the sidewalk surface conduit would doubtless be preferred on account of its accessibility for looping and changing. For trunk lines where the required number of conductors is definitely

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known, or where provision may be made in advance for future need, the cables may be permanently placed in boxes made of plank or iron, filled in with pitch, and will require no further attention.

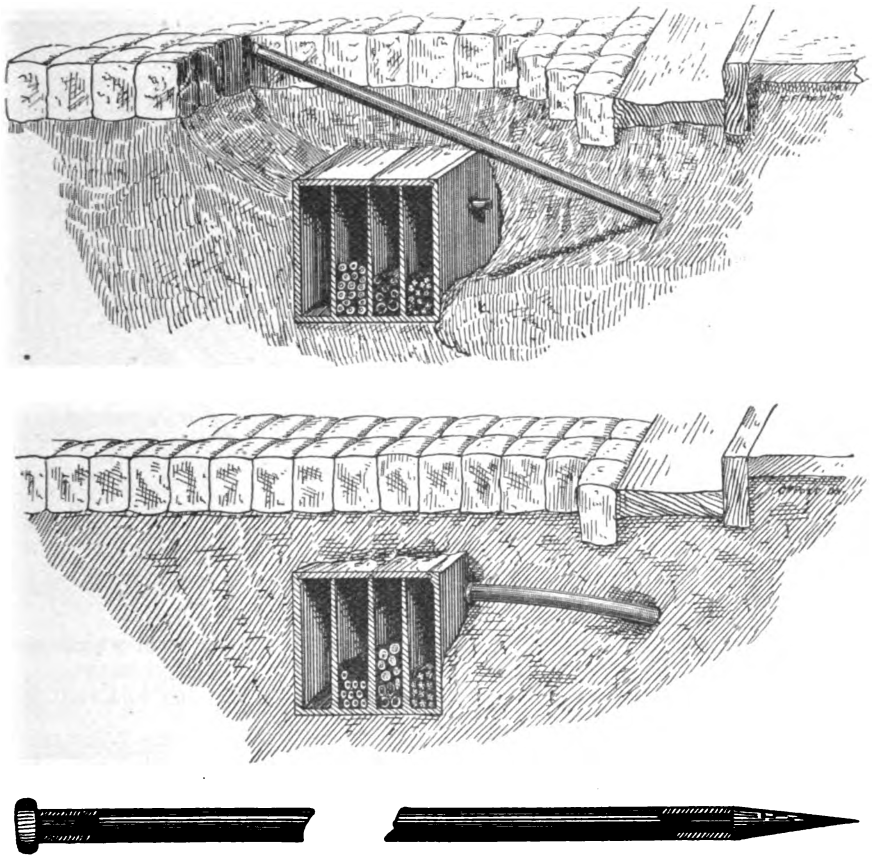

FIGURE 4.

All of the surface conduits referred to, and shown in the various illustrations, are so laid that the lid of the box is flush with the flagging, or as near the surface as practicable. The details of wire distribution are shown in figure 1, where conductors branch from the conduit to test and connection boxes, fire-alarm boxes on lamp-posts, and electric light poles or standards. The different blocks also show various methods of house-to-house distribution. In block

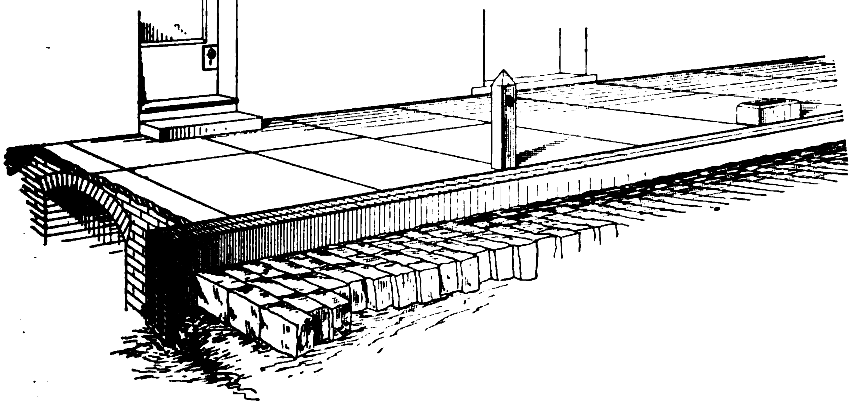

FIGURE 5.

number 4, the wires are distributed to the east side, from a pole in the courtyard while on the west side they are led through the vaults. In blocks 3, 5 and 7 the wires are distributed by cables running from vault to vault, while in 6 and 9 the different houses are served direct from the conduit to the vault or cellar; blocks 8 and 12 are served from a pole located in the yard near the centre; block 10 has a roof box from which the wires are run along the housetops.

Should it be required that every house be reached by

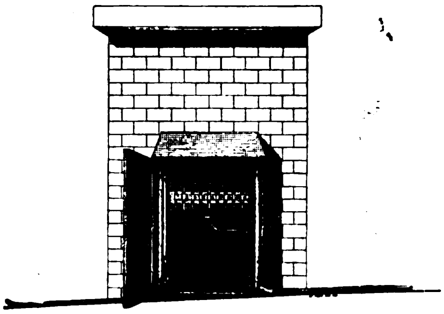

FIGURE 11.

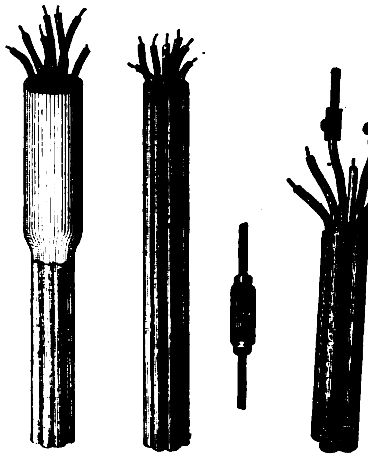

FIGURE 14.

wires which are underground their entire length, branches from either the sidewalk or street conduit may be made direct to the cellar. This may be accomplished by using a piece of gas pipe provided with a pointed tip and driving-head which may be driven under the walk to the front wall as shown in figure 4. In some cases it will be found more

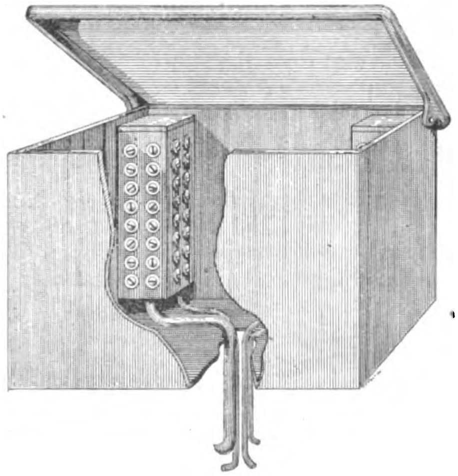

FIGURE 13.

convenient to drive from inside the vault or cellar to the conduit. Usually this can be done without disturbing the sidewalk. The cable is sufficiently stiff to permit of its being pushed through the short section of gas pipe leading from the conduit to the cellar.

In those cases where it may be found desirable to lead

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the cable from vault to vault and thus avoid disturbance of the street, a distribution box may be placed in the first vault reached, the wires and cables being identified and numbered as they are brought in from the conduit. The inside wires may be subsequently connected at this box as required.

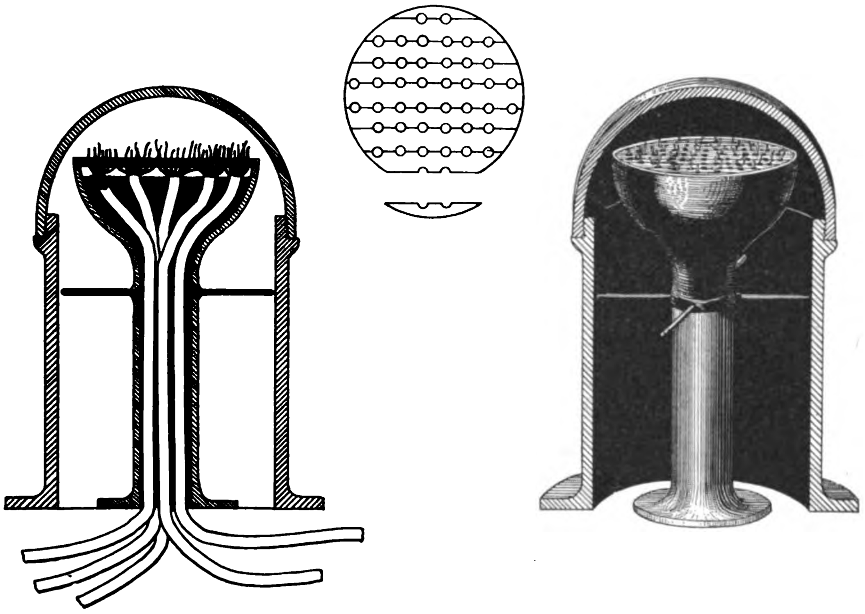


FIGURE 12.

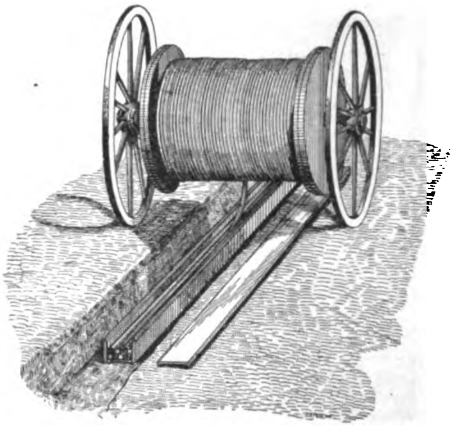


FIGURE 16.

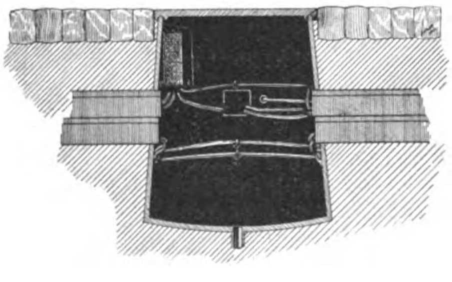


FIGURE 10.

Pole and roof distribution may be resorted to where it is not imperative that the entire length of the wires should be placed underground. In figure 1, blocks 4, 8 and 12, the cable is led from the conduit to a test box on a pole, located near the centre of a block, from which the distribution may be made direct to such rear windows as it may be necessary to reach, or by a roof cable from which wires may be dropped to the windows in the usual manner. In block number 10 a cable is shown extended to a roof box, and figure 11 is an elevation of such a box. In practice it would doubtless be desirable that the conduit or cable company should extend its conductors only to the distribution

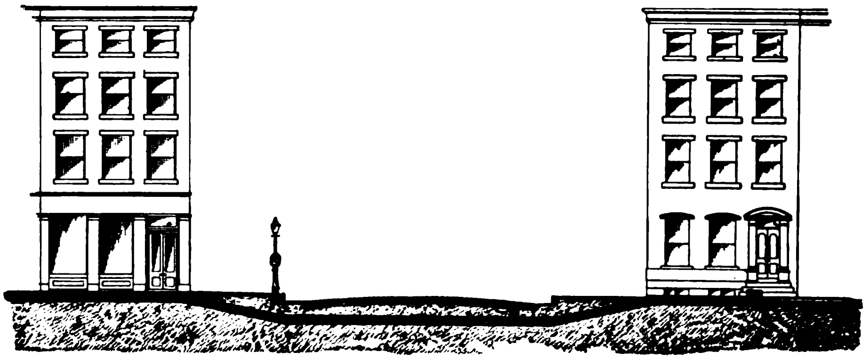
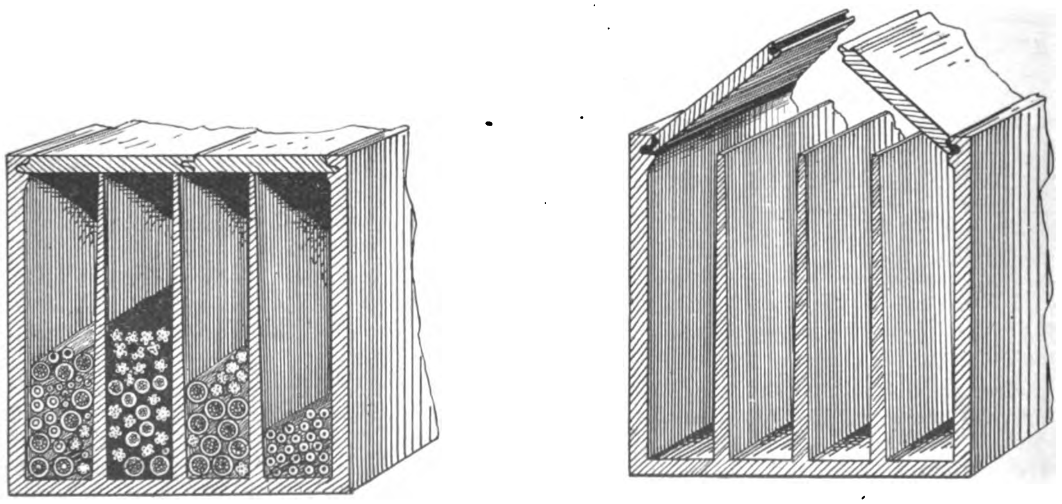


FIGURE 8.



CLOSED. FIGURE 2. OPEN.

boxes, from whence the electric service company should distribute the necessary wires to its subscribers.

The general use of man-holes in connection with this system is entirely obviated, it being considered that the objections to them outweigh the advantages gained, although in special cases they may be found useful. The

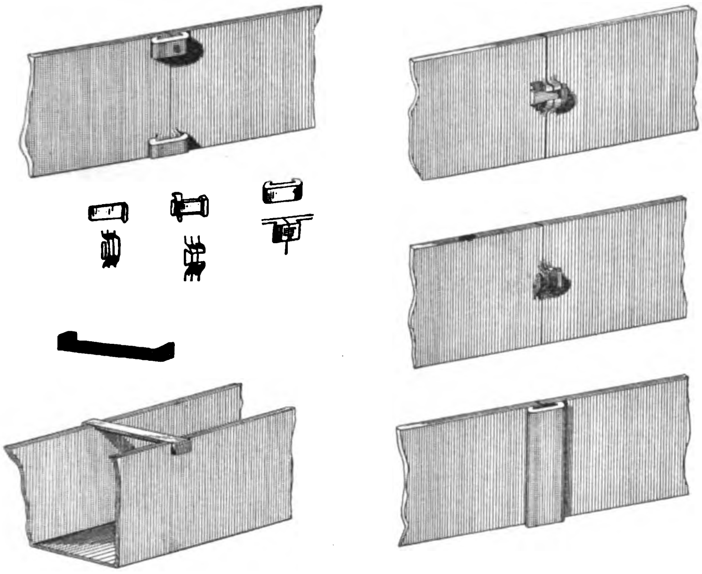


FIGURE 3.

cables are laid in from the reel, as shown in figure 16, instead of being pulled in, as is frequently the case with subterranean conduits. The connection or test-boxes as shown in detail by figures 12 and 13 are far preferable for the necessary manipulation of wires, and may be made of any

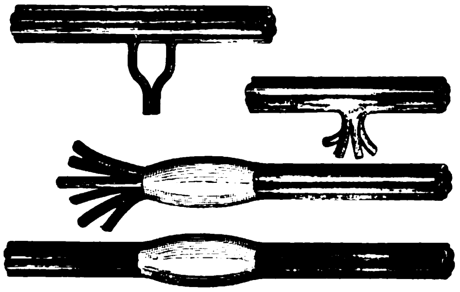


FIGURE 15.

desired size. Figures 5 and 13 show a box of this character, so designed and placed as to be utilized for a stepping stone which will prevent any objection which a property owner might otherwise make against the placing of a structure opposite the door of either his business house or dwelling. A ring is attached to the lid, which serves the double

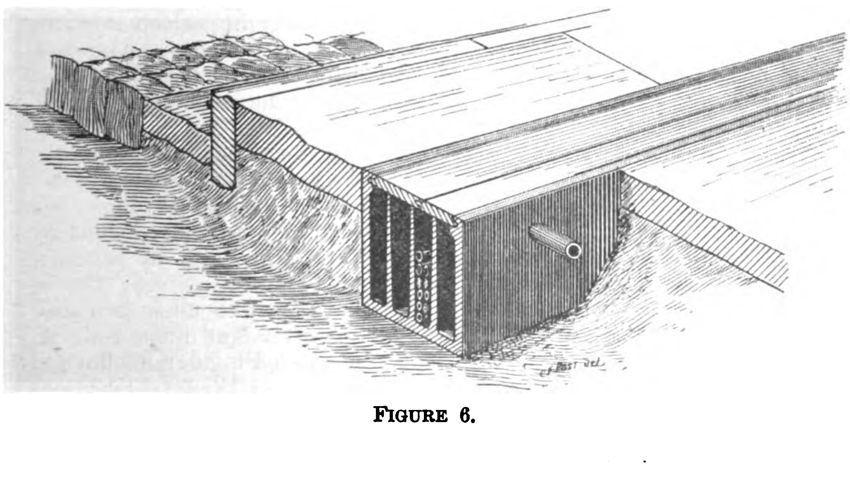
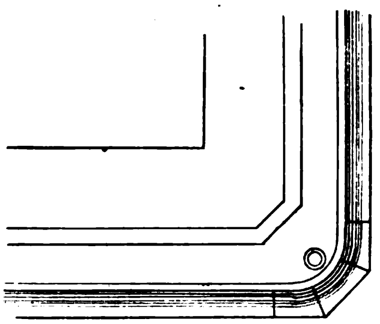


FIGURE 6.

purpose of a handle, and a place for hitching horses. The proposed dimensions, as shown in figure 13, are 12″ x 12″ x 18″ which will accommodate from 300 to 500 wires. The cables are led into the inner box as shown in the cut, the wires connected to the screws, when if desired, the inside compartment may be filled with pitch or asphalt. Conveniences are thus afforded for testing any wire entering the



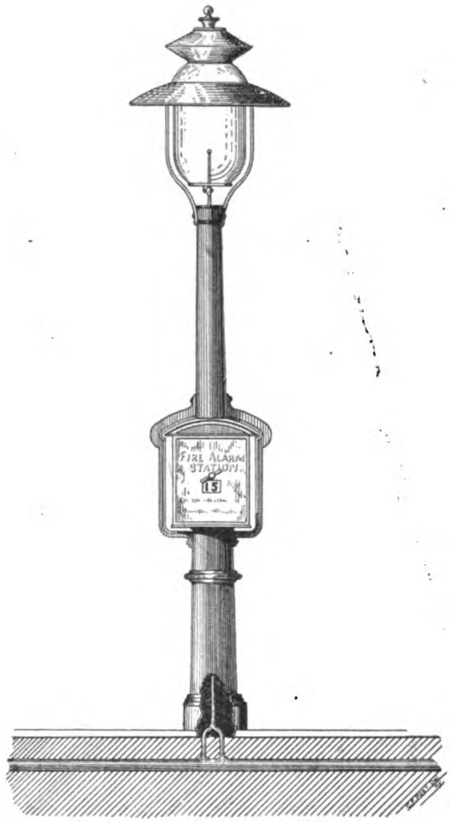


FIGURE 17.

box, for making cross connections, branching to other cables, or for local distribution through the block where it is located. For the latter purpose communication between the block and the box would be effected by a short local cable, and the necessary connections between the local and main cables may be readily made between the terminals of the wires at the screws as shown. Such a test-box is cheap, has a watertight cover and being above the street level its interior remains dry. It is convenient of access, permits the entrance of light when open, and can be made as much larger as circumstances may require. Figure 12 shows another surface test-box, possessing similar advantages. Its adaptation for the purpose is apparent from examination of the cut. The cables are brought up into the distributing bowl, the wires spread out and extended through the perforated diaphragm which is made in sections to permit

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access to the interior without disturbing all the conductors, each perforation having its proper number for identification of the wires. The bowl may be filled with pitch or any suitable insulating compound.

Figure 10 shows a section of a man-hole with details of the mode of connecting or branching the conductors leading into it. "Through" wires or cables are shown passing directly through without branching. These are carried along the sides of the interior upon special hooks or hangers, in order to allow the largest possible working space. A test-box similar in construction to the stepping-stone box already described, and for a similar purpose is shown near the top of the man-hole. Cables branching in various directions are also shown.

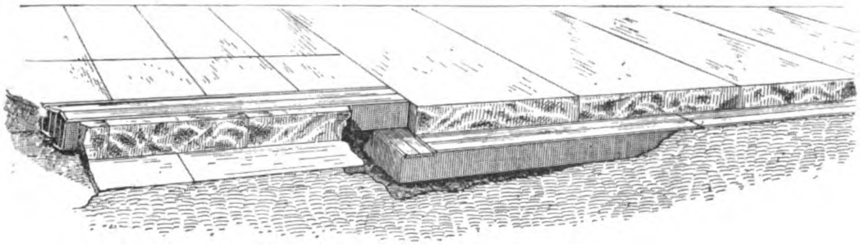

FIGURE 7.—Perspective showing mode of transferring from sidewalk surface conduit to gutter surface conduit.

Instead of filling the distribution boxes with insulating material, which might in some cases be objectionable, a special cup of lead may be fitted to each cable into which after the cable conductors have been spliced to the leading-out wires, the insulating material may be poured, thus sealing up the cable end and completely protecting it, as shown in figure 14.

Figure 8 is a sectional view of a street crossing where the conduit dips slightly below the surface and connects with the sidewalk conduits upon each side. The use of portable bridges for temporarily covering the trench where the men are not actually working will prevent any obstruction to travel. Such a bridge may even be used where the workmen are actually engaged, as it can be readily removed and replaced for the accommodation of vehicles, without appreciable loss of time.

FIGURE 9.—Section showing house-connection from vault to vault.

Figure 2 is a sectional view of the compartment conduit, divided as shown by suitable partitions which like the box are of iron, and may be cast with it in one piece. Wires for different classes of electrical service may be run in separate compartments, or trunk wires may be run in an inner compartment, and local wires in the outside divisions for convenience in branching. Should it be desirable to treat certain wires or cables in a different manner, as for instance to cover them with a special protecting mixture which in other cases is omitted, the division of the box permits it to be readily done, while the support given to the cover by the partitions adds to the strength of the whole structure. In figure 2 may be seen also the simple and convenient shutter-lid, which is easily opened or closed, and automatically adapts itself to position. The whole or half of the cover may be removed as desired. This form of lid facilitates access to any part of the conduit for the purpose of making necessary connections. Figure 3 shows the details of several plans for joining sections of the conduit. No attempt is made to prevent the access of air, gas, or moisture. The vacant space is insufficient and the loose joints of the box too near the surface to permit the dangerous accumulation of explosive or deleterious gases, while water-tight conduits are more expensive, and wholly unnecessary where the cables of this company are used.

In figure 15 are shown several modes of branching, looping, and splicing, and in figures 8 and 17 the manner in which the looping is practically carried out in connection with the fire-alarm telegraph boxes at various points in New York city, where these cables are used.

Figure 6 shows a surface conduit located near the centre of the sidewalk where it avoids the line of lamp-posts, hydrants, etc. The piece of pipe extending from the side indicates the process of introducing a wire or cable into the vault or cellar of an adjacent building.

The various illustrations give a very clear idea of the exhaustive and practical manner in which this important question of subterranean work has been treated in connection with the use of the Waring wire and cables. These have been thoroughly and scientifically tested for practical work, and those who use them constantly in New York, Philadelphia, Washington and other cities are fully satisfied that they are permanently reliable. There is, apparently, no doubt but that a local subterranean system arranged upon this plan would provide a more satisfactory and continuous electrical service than has been introduced from the construction of the first telegraph line down to the present day.

LIABILITIES OF TELEGRAPH COMPANIES AS AFFECTED BY PRINTED CONDITIONS.

BY J. P. KIRLIN.

HAVING in previous articles considered the effect of certain stipulations and regulations, usually found in telegraph blanks, on the sender's rights over or against the company for failure to deliver or for improper delivery of his message, I now come to the discussion of two questions of a somewhat different character. Heretofore the points presented have had reference solely to the sender of a despatch, and to the limitations placed or attempted to be placed by the companies on his legal prerogative. But obviously the person addressed, also if he acts on an altered or delayed message, may have sustained a loss. He cannot recover such loss from the sender of the message, because there is no contract with him. The minds of the parties have not met on the same proposition. Still he should not be wholly without a remedy. And beyond the question, who can bring a suit, lies the other and equally important consideration, how much of a real loss in any case is recoverable? The two points to which attention is now directed may be formulated as follows: First, what rights has a receiver who sustains no contractual relation to the company, but who through its neglect has suffered damage? And secondly, what is the measure of damages recoverable in suits by senders of messages, and in actions by receivers?

The leading case on the receiver's rights arose in a singular way, and brought up all the attendant difficulties. A message was sent from New York to a Philadelphia florist, couched in these words: "Send me for Wednesday evening *two hand bouquets* one of five and one of ten dollars."

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The operator in Philadelphia understood *hand* as *hund*, and evolving from his inner consciousness, the conclusion that this was an abbreviation for hundred added the *r-e-d* and the message was delivered to the receiver: "Send me for Wednesday evening *two hundred bouquets.*" Before the mistake was discovered many valuable flowers had been cut to make the two hundred bouquets, and the receiver proposed to look to the telegraph company to make good the consequent loss. The court allowed him to recover, and in delivering judgment placed it upon this ground, "The wrong of which the plaintiff complains consists in sending him a different message from that which they had contracted to send. That it was a wrong is as certain as that it was their duty to transmit the very message prescribed. To follow copy, an imperative duty of the printing office, is equally applicable to the telegraph office." The rule is plainly laid down, the receiver's right is acknowledged, and the principle is now universally accepted throughout the states. But the result is only an anomaly, a settled body of law without a leg in principle to stand upon. A little careful consideration will show that we appear to have here, a rule without a reason.

The holding in England is directly opposed to the one above laid down; and while the principle of our courts appears best to square itself with justice the reasoning of the foreign courts is difficult to escape. They say the receiver is without remedy for the reason that he has suffered no injury. Injury in a legal sense, *injuria*, stands for the violation of a legal right. Damage he unquestionably may suffer, but damage alone without *injuria* gives no right of action. If, therefore, he is unable to establish the violation of some acknowledged right, he is remediless. Now what right has he which can be infringed? Plainly he cannot claim to sue on a contract, because he has no contract upon which to sue. The contract of the company is made with the sender. He cannot sue for a deceit for the indispensable element of bad faith is wanting. He cannot sue for negligence, because the negligence, if any there be, is wholly in and about the performance of a contract; and to allow a stranger to sue for that negligence would be equivalent to letting him sue on the contract itself. Moreover negligence being the want of care, it would seem no action would lie on that ground because there is no contract with him under which the company owes him any care. But despite these conclusions our courts allow the receiver within certain prescribed limits to recover; and have attempted to rest his right on various different grounds.

It has been said in some instances that by reason of its public calling a telegraph company is under certain public duties, is a public agent so to speak, and that for any failure to use due care in the conduct of its business a remedy may be had by the person thereby injured. But this position is clearly untenable. The only public duties a company is under consist in its obligation to individuals to serve all who desire to employ it, without distinction, and to the state to continue the proper performance of its duties according to the tenor of its charter. Obviously these are not duties of which a breach can in any way affect a person addressed. Before he can seek redress there must be some ground for predicating care as to him, and then for negligence, a want of such care, compensation may be sought.

Other cases have rested this right on the principle that the receiver is the beneficiary of the contract, and that as it is made for his benefit he should be permitted to sue for its breach. This ground is also open to objection and limitation. In ordinary affairs the mere fact that a person would receive profit from a certain contract, would give him no right of action for its breach. The relation of privity would be wanting. At most this rule would only cover the small number of cases in which it appears from the message itself that it is for the benefit of the receiver; for there is an exception in this country that where a contract is expressly made for the benefit of a third person, he can bring suit for its breach. But this distinction has not been taken in the cases. The rule has been broadly laid down—and wrongly.

It has been further attempted to sustain this holding on the ground that the message is the property of the person addressed; and in support of this view refuge has been sought in the analogy of property in a letter. The analogy is unfortunate, because it does not bear out the principle. All the property the receiver of a letter has, is in the paper on which the intelligence is written. He has no title to the matter in the letter as has often been determined. This remains the property of the writer as being the product of his intellect. Now as the receiver of a letter can only be said at most to own the paper on which the communication is written, and as a telegraph company transmits the intelligence alone without the paper, the analogy of property in a letter is plainly a failure. The analogy of a consignee of goods has also been suggested. But in such a case the consignee can only recover where he is the owner of the goods before they are sent, or where the sender is his agent. And as the receiver is never owner, in this sense, and as when he is principal to his agent the actual sender, he should sue as sender, and not as receiver, this analogy is equally worthless with the other.

Other grounds have been given but upon examination they too prove insubstantial. The rule is in fact an exception to general principles and should be so stated. It is one of the cases where the courts have stepped aside from law to tread the path of justice. The business of telegraph companies is only that of making representations. They deliver certain matter to the receiver and if reasonable on its face he naturally acts upon it. And in doing so he simply follows the current of affairs. Because the companies make large profits through these representations, it is right that they should make them with care. And as this is the only reason of their being, a sound public policy would appear to dictate that for any want of care, they should respond in damages. Such a rule would place the matter on a rational basis.

I have stated, however, that the right of a receiver is prescribed by certain definite limits. These are that he must have acted on the faith of the message being proper, and that in doing this he must not himself be guilty of contributory negligence. By contributory negligence is meant negligence on his part without which the loss would not have happened. An illustration will best explain the working of this rule. Take for example a message containing an error. If he has no reason to suspect the error and acts on it, no blame is imputable to him. But if the error is apparent, then what? The rule here is that he may even interpret such a despatch reasonably. If however the message is wholly insensible, and he attempts to interpret it, and does so wrongly, his recovery would be barred. A leading case in this state occurred respecting the following: "Edward De Rutte, San Francisco: Buy x x a shipload of x x white wheat first quality, extreme limit *twenty-two* francs *hectolitre* landed at Bordeaux, same conditions as the *Monod* contract. *Th.* De Rutte." As read, the message ran: "Buy x x a shipload of x x white wheat first quality extreme limit *twenty-five* francs *pretorlitière* landed at Bordeaux same conditions as *monied* contract, *Thos.* De Rutte." Since all the errors save the one respecting the price were perfectly apparent, and their real meaning plain, the court held he was justified in interpreting it and acting on it as interpreted, and that for the loss arising from a purchase at twenty-five instead of twenty-two francs the company was liable. Another case will show the limits to which interpretation may go. A message concerning stock transactions was sent to a broker as follows: "Hatch says *hold undoubted.*" This despatch as received read: "Hatch says *sold undoubled.*" The broker interpreted this as an order to sell and having sold at a loss brought an action to recover. He failed. The court held the

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negligence of the company was not the cause of the loss. The message received was an unintelligible jargon, and in treating it as an order to sell, the agent took the risk of the interpretation. These two cases plainly illustrate both the rule and its limitation.

In discussing the second question propounded at the head of this article a distinction is taken between the damages recoverable by a sender and by a receiver, for the reason that the suits proceed upon a different theory. The action of the sender is governed by the laws of contract, that of the receiver by the rules of tort. But in either case the limit is actual compensation. The utmost that can be recovered is the actual amount of the loss. But while the plaintiff cannot as a rule recover a sum greater than is co-extensive with his loss, it does not follow that in every case he can recover even this amount. The rule in contract is that the plaintiff will recover, if at all, a sum which might reasonably have been contemplated by the parties at the making of the contract, as a proper satisfaction for its breach; in tort, the damages which are in satisfaction of the natural and proximate consequence of the defendant's act,—are in other words in satisfaction of the loss that might reasonably have been expected under the particular circumstances to flow from the defendant's act. Practically, therefore, a receiver will recover his actual loss, but not always a sender. The rule to be applied to him was laid down many years ago in these words: "Where two parties have made a contract which one of them has broken, the damages which the other party ought to receive in respect of such breach of contract should be such as may fairly and reasonably be considered either as arising naturally, *i. e.*, according to the usual course of things, from such breach of contract itself, or such as may reasonably be supposed to have been in the contemplation of both parties, at the time they made the contract, as the probable result of the breach of it. Now, if the special circumstances under which the contract was actually made were communicated by the plaintiffs to the defendants, and thus known to both parties, the damages resulting from the breach of such a contract, which they would reasonably contemplate, would be the amount of injury which would ordinarily follow from a breach of contract under these special circumstances so known and communicated. But, on the other hand, if these special circumstances were wholly unknown to the party breaking the contract, he, at the most, could only be supposed to have had in his contemplation the amount of injury which would arise generally, and in the great multitude of cases not affected by any special circumstances, from such a breach of contract; for, had the special circumstances been known, the parties might have specially provided for the breach of contract by special terms as to the damages in that case; and of this advantage it would be very unjust to deprive them." And lately it has been reiterated as follows: "The broad general rule in such cases is that the party injured is entitled to recover all his damages, including gains prevented as well as losses sustained; and this rule is subject to but two conditions,—the damages must be such as may fairly be supposed to have entered into the contemplation of the parties when they made the contract, that is, must be such as might naturally be expected to follow its violation; and they must be certain, both in their nature and in respect to the cause from which they proceed."

It may happen, therefore, under this rule that a sender will recover but a nominal sum when he has in fact sustained a heavy loss, because the terms of his message do not show that if it is not sent such a loss will follow. At the first blush this seems a trifle unjust. But it must be borne in mind, the sender when he offers his message can preserve his rights in this regard by stating to the operator the damage that will ensue in case of failure to deliver it properly. This indeed is the only safe way in the great majority of cases.

STATISTICS OF UNITED STATES PATENTS ISSUED IN 1885.

COMPILED BY THOS. D. LOCKWOOD.

THE total number of patents on all classes issued in the year 1885 is 23,330. The total number of patents issued on electrical subjects or in which electricity is a feature is 1,358. The electrical patents issued in 1885 constitute 5.78 per cent. of the whole.

Of the above, the patents relating more or less nearly to telephonic communications may be divided into eleven sub-classes as follows:

1. Switchboards	17
2. Central office apparatus	36
3. Abnormal current guards and lightning arresters	29
4. Battery telephones or transmitters so-called	45
5. Miscellaneous telephonic utilizations	5
6. Telephone signals	28
7. Receiving telephones	32
8. Telephone exchange systems and circuit arrangements	24
9. Mechanical telephones	15
10. Remedies for induction, etc	18
11. Telephonic relays and repeaters	2
Giving a total of	251

Patents relating generally to the distribution of electricity, and to the electrical transmission of power, number 119, and are comprised in the following sub-classes:

1. Distribution of electricity	30
2. Railways and locomotors	45
3. Transmission of power, telpherage and stationary motors	44

Sources of electricity and kindred patents give a total of 151, and are comprised in the following sub-classes:

Dynamo-electric machines and parts	67
Dynamo regulators	21
Primary batteries	37
Secondary batteries	26

Conductors, insulators and supports give a total of 156, and are subdivided as follows:

1. Insulated wires, flexible cords, etc	17
2. Line wires, etc	14
3. Insulators	11
4. Couplings, conductors and screwposts	15
5. Cables and compound conductors	28
6. Underground systems, etc	47
7. Insulating Compounds	13
8. Supports, poles, fixtures and cable hangers	11

Telegraphic systems and instruments give a total of 123, and comprise the following sub-divisions:

1. Printing telegraphs	49
2. Multiple do	36
3. Automatic do	7
4. Novel systems of telegraphy	9
5. Keys, relays, sounders, etc	22

Well-known applications of electricity are enumerated as follows, and show a total of 233.

1. Clocks, synchronizing and time systems	25
2. Annunciators, alarms, bells, etc	50
3. Burglar alarms, watchmen detectors, etc	11
4. Fire alarms and district systems	33
5. Railway signaling	42
6. Measurement, galvanometers, etc	12
7. Electro magnets, armatures and induction coils	12
8. Circuit breakers, closers, changers and controllers	25
9. Gas lighting	23

Patents relating to electric illumination give a total of 183, divided among the following sub-classes:

1. Lamp fixtures	31
2 Lighting apparatus, cut-outs, etc	27
3. Incandescent lamps, parts and processes	57
4. Arc lamps	68

Miscellaneous applications, 136.

The subject of telephony is thus seen to still hold its own in the inventive mind, and is well in the foreground.

Considering the inventors alphabetically, we find them arranged as follows:

A = 24; B = 100; C = 76; D = 62; E = 33; F =

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64; G = 50; H = 93; I = 3; J = 32; K = 24; L = 49; M = 103; N = 21; O = 20; P = 99; Q = 0; R = 48; S = 199; T = 63; U = 1; V = 59; W = 128; X = 0; Y = 6; Z = 1.

The letter S as usual has a quite noticeable plurality—perhaps owing to its crooked ways—W filling the second place, M being third and B fourth. The letters Q and X, as might be expected, are unrepresented, while U and Z each do their part nobly with a single candidate.

The number of electrical patents issued in 1884 was 1,146. The balance in favor of 1885 is 212.

THE PRESENT STATUS OF ELECTRIC LIGHTING IN LONDON.

BY DAVID E. LAIN, B. S.

WHILE it would be quite far from the truth to say that little use is made of the electric light in London, yet, to an American, the Londoners appear to be far behind the age in the use of this most satisfactory artificial light. Before arraigning the people of this city as slow in appreciating the advantage of the electric light, justice demands that the peculiar conditions of their case should be explained.

In the first place, the gas supply of all London is controlled by one very wealthy and powerful company. It is prepared to fight the electric lighting interests to the end. When some electric lighting companies gave an exhibition of their systems by lighting the embankments along the Thames river about two years ago, the gas company found it to their interest to not only reduce the price of street lights but to considerably increase the number of street lamps in certain parts of the town, so that now the streets are very well lighted at an expense little above the actual cost of the gas used.

Of course no electric lighting company in this country can at present undertake to furnish electric light at or below the first cost of the gas necessary to produce an equal illumination. This will be seen to be quite sufficient to give the gas company a complete victory as far as street lighting in London is concerned.

For interior lighting the price of gas is about 2s. 8d. per 1,000 feet. Even at this low rate it is claimed that electricity could be made a successful competitor for inside lighting—making fair allowance for the acknowledged superiority of electricity over gas for illuminating purposes—if its friends were not further hampered by certain requirements of the law.

The particular act of Parliament which those interested in electric lighting in England are unanimous in disapproving is known as the "Electric Lighting Act of 1882." This act is avowedly to "Facilitate and regulate the supply of electricity for lighting and other purposes in Great Britain and Ireland."

Just how it "facilitates" such supply is not so easy to find from the reading of the act. But how it "regulates" the business is quite obvious. According to the requirements of this act, any "company or person" undertaking to supply electricity for public or private purposes must obtain a "license from the Board of Trade." Such "license shall be for any period not exceeding seven years" but may "be renewed from time to time for a like period upon such terms and conditions as the Board of Trade may determine."

Also the "local authority within whose jurisdiction the area served with electricity is located may within six months after the expiration of a period of twenty-one (21) years or such shorter period as is specified, and within six months after the expiration of every subsequent period of seven years or such shorter period as is specified, by notice in writing shall require such company or person to sell, and thereupon such undertakers shall sell, to them (the local authority) their undertaking upon terms of paying the then fair market value of the property, but without any addition in respect of compulsory purchase or of good will or of any profits which may or might have been or be made from the undertaking, or of any similar considerations."

The enforcing of this act is regarded as a very serious obstacle in the way of obtaining capital for the prosecuting of electric lighting on the central station system. The hope is expressed in electrical circles that this act may soon be repealed.

In the mean time the method resorted to by the only company in London furnishing electricity from a central station is to make special contracts with the consumers of the electricity whereby they contract themselves both out of the protection and restriction of the act. The wire for conducting the current is supported on poles attached to the house tops of the patrons, since by a recent act of Parliament a wire may pass over property without the consent of its owner, if it in no way touches the property. By this means this company claims that it is neither protected nor restricted by the electric lighting act of 1882.

The company referred to is the National Company for the Distribution of Electricity by Secondary Generators, using the patents of MM., Gaulard and Gibbs. The central station is in New Bond street, nnder the Grosvenor Gallery. At this station they use a large type of the Siemens alternate current dynamo. These dynamos each give a current of 33 ampères and 250 volts at 550 revolutions of the armature per minute. At this speed there are 16,500 reversals of the current per minute.

This system comprises the use of a main circuit on which there are a number of so-called secondary generators or induction coils. These secondary generators are placed in the buildings to be lighted. The current used for lighting is induced in the secondary coils of the generators by the alternating current in the primary coils. The chief advantages claimed for this system is that the cost of conductors is greatly reduced, and the consumer can have the number of ampères in the current served to him any desired multiple of the volts. For instance, in a Kainite mine at Ascherslieben, Germany, which is lighted by this system, there are incandescent lamps, arc lamps, motors, and electrolytic decomposing cells, all simultaneously supplied by the same dynamos; and each is given a properly proportioned current, by means of the secondary generators, which are claimed to show an efficiency of from 89 to 95 per cent. Of course the current for the decomposing cells has to be commuted.

The station in London has been in running order for but a few months, but already it is serving electricity to about 5,000, 20 c.p., incandescent lamps and about 20 arc lamps, varying in power from 1,000 to 3,500 candles.

That there are several very important arguments in favor of the system used by this company is obvious, but whether they will succeed in practically overcoming a number of grave problems introduced by the use of an alternating current of high E. M. F., yet remains to be seen. At any rate the enterprise displayed by this company is worthy of substantial encouragement by the light users of London.

At present very little use is made of the electric light in private residences in London. Its use is quite exclusively confined to cafés, restaurants, club rooms, shops (or as we say stores), etc.

Beside the light furnished by the company above referred to, there are quite a number of cafés, shops, etc., lighted on the isolated plant system, but the difference in cost of light produced in this way as compared to gas is so much in favor of the latter that comparatively little progress has been made. The only hope for London, or in fact for any city, to obtain electric light at popular prices seems at present to depend on the central station system.

The almost inconsiderable use made of the arc lamp here is certainly worty of mention.

As far as I can learn there is no legislation that directly favors the incandescent in preference to the arc system. Section 26 of the Electric Lighting act of 1882, might pos-

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sibly be construed as being more of an obstacle to the extended use of the arc than of the incandescent lamp. This section requires that no electric line must by induction or otherwise, interfere with the proper working of any telegraph line of the general post-office.

If the currents used for arc lighting were believed to be more dangerous to the proper working of the telegraph than those needed for incandescent lamps, the above section might be considered as favoring the latter system.

But it must be remembered that by the consent of the property owners to whose ownings the supports are attached —a consent not always easily obtained here—electric conductors may be and are carried overhead in London. So that it is not always necessary that these conductors be placed underground, and thus harmful proximity to the telegraph lines could usually be avoided.

The stringent requirements of the act above referred to, both as to the length of time which an electric lighting company may continue its business and also to their obtaining right of way for their conductors, can justly be considered as unfavorable to electric lighting interests. But that its requirements are more unfavorable to arc lighting than to incandescent lighting is not so apparent.

The peculiar forte of arc lamps seems to be in street lighting. On account of reasons already given, both it and the incandescent lamp have been driven from this field in London by the gas company. While for interior illumination the people of London have decided in favor of the incandescent lamp, the universal fear of high potential currents that seems to exist in the minds of the London public undoubtedly has much to do with this decision. But now that it is made, the incandescent lamp will probably enjoy the supremacy here over its more powerful brother for a long time to come.

One finds an occasional shop-keeper who uses either the arc lamp or the Jablochkoff candle for illuminating his show windows and the street in front of his place of business. This is about the only use at present made of the arc lamp in London and this is really quite inconsiderable.

LONDON, December 28, 1885.

ECONOMY TEST AT THE HARRISBURG (PENN.) STATION, EDISON SYSTEM.

THE following report of a test in evaporation, etc., is taken from the original elaborate report issued from the Edison company's office in New York. This central station of the Harrisburg Electric Light Co. is what is called an over-head wire station. The boilers were in battery, set with the Jarvis patent furnace. The report was submitted by Mr. Wm. J. Hammer, chief inspector.

In conjunction with the investigation of the Harrisburg central station, an important economy test was carried out (August 29th and 30th) covering a 12-hour run, from 6 P. M. to 6 A. M., to determine the efficiency and reliability of the various station units as well as the economy of working of a typical Edison central station working under the normal condition of load, etc. Twelve persons took part in the test, and through a systematizing of the arrangements of the tests beforehand, the tests of boilers, engines, dynamos, testing instruments, readings, indicator cards, etc., were taken upon the stroke of a gong at stated periods; all time-pieces being set to one standard. The apparatus used was of a standard pattern compared with accurate standards. The measurements and weight of water and fuel were taken by Mr. Hammond, of the Jarvis Engineering Co., and Mr. Beggs, treasurer and general manager of the Harrisburg Electric Light Co. The scales employed were tested with U. S. standard weights, and the water measured in a standard tank; the water being run into same to a given level and weighed by the above standards. The temperatures of water in tank and feed water, were taken with standard thermometers reading to 10ths of a degree, and checked by standard thermometer having a "Yale" certificate. The temperature of gases in the stacks were taken with a pyrometer supplied by the Jarvis Engineering Co. The stacks being of iron, and two boilers work- into each stack, an opening was made into each and the temperatures were taken alternately. During the running of the three boilers (one boiler not being used in test) the difference in the temperatures in the two stacks was inconsiderable. The draft in the two stacks was taken by means of the apparatus devised by Prof. Burkett Webb, of Cornell University, the same having been endorsed by the Franklin Institute test committee, of Philadelphia. During the test, no water was thrown under the grate, and the fuel contained only the moisture which it contained when delivered, *i. e.*, 1.77 per cent., which was allowed for in the calculations. The mixture used during the test was three parts of anthracite screenings to one of soft coal (Clearfield bituminous). The value of this mixture being $1.2275 per ton of 2,000 pounds delivered in station.

Prior to the test, an examination was made of the boilers and they were blown off and cleared thoroughly; they were then brought up to their normal working pressure, and, at the time of the start, the fires were quickly drawn, the furnace and ash-pits cleaned, and new fires started with 600 pounds of wood. The coal used in starting the fires was a trifle richer than 3 parts screenings to one of soft coal, but later this was allowed for, so as to maintain these proportions throughout. A strip of black court-plaster was pasted at the height of the water in the gauge-glass, and the water held at the same height at the end of the run. The conditions at the start were maintained the same, so far as concerned the boiler pressure, height of water, etc. No fuel remained on the grates at the end of the test, the last serving being worked very close.

The temperatures of the feed water were taken from water drawn into a pail from the feed in pipe midway between the heater and boiler; the first pail-full in each case being poured away to prevent loss by cooling in the pail. Tests were also made at the heater, and at the points of feeding into the boilers. The water was supplied to the standard measuring tank from the city mains, and drawn into a reservoir beneath and pumped thence through the feed water heater by a "New Era" pump, which was backed up by a Korting injector. Cards taken from the pump showed an average of 1 h. p. ind. Immediately after the test the fires were drawn, and all ashes and refuse weighed on the fuel scales.

The steam pressure was taken from a standard gauge which had been tested previously at the Pennsylvania railroad car shops. The individual gauges which read closely were not considered.

The showing, so far as the boilers were concerned, was admirable, and speak well for the Jarvis patent boiler setting with which they were set. The boilers (of which the station has four) are of the single return tubular type. Their principal dimensions are as follows:

Diameter of shell	72 in.
Length of shell	15 ft.
No. of tubes	120
Diameter of tubes	3 in.
Length of tubes	15 ft.
Width of furnace	75 in.
Length of furnace	72 in.

Grate bars; ten full bars 6″ x 6′ Deep side bars with arc cross-sections 5-16 inch thick.

Width of air spaces, ⅝ inches.

Air space is 50 per cent. of grate surface.

Height of chimney	70 ft.
Diameter of drain at base	46 in.
Diameter of drain at top	52 in.
Area of chimney	1,661 sq. in.

(Two boilers connected to one stack.)

Draught area through tubes, 729.96 sq. in. to each boiler.

Area of smoke-box	729.61 sq. in.
Area of grate surface	37.43 sq. in.
Total heating surface	1,626 sq. ft.

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Steam space..............................99.14 cu. ft.
Water space..............................236.66 cu. ft.
Mean water line........6¼ inches above top row of tubes.

The electrical tests were carried out as follows: Two standard E. M. F. indicator testing boxes, which had previously been compared, were connected at the ends of the omnibus wires in the station, and indications were frequently taken to determine the variation on both sides of the three-wire system. Upon the next floor, in the rear, a room was fitted up for taking readings from time to time, by means of a Thomson reflecting galvanometer, which was used to check off the readings of the main, neutral and individual (shunt) ampèremeters in the dynamo room down stairs; which readings were taken at the stroke of the gong. The various machines used in the test were of the No. 20 type, 400 ampères, were tested individually and in pairs, and by means of a large switch they were connected through a german-silver shunt, having a capacity of 1,200 ampères.

Prior to the test, tests were made of the dynamos as to insulation, faults, etc., and they were found in perfect order. Tests of their speeds were taken throughout the test, which showed but a slight variation.

In the general characteristics the Harrisburg station may be considered the standard Edison central station. It has been constructed both with an eye to efficiency, reliability and permanency. Though constructed by the local parties the company has not spared trouble or expense in putting in a station alike creditable to themselves and to the present management of the New York company, which has broadened out its field of work by a more liberal treatment of the vital issues of its central station business.

Ground was broken in Harrisburg, February 1, 1885, and the current turned on to 2,000 lamps May 1, 1885, there being no less than 3,000 lamps connected at that date.

One of the important facts demonstrated by this station is that it is far preferable to start a station with a large number of consumers, than commencing in a small way and working up to a fair output. It has also been demonstrated to be a more feasible plan. The fact that this station, since its inception, has been on a dividend-paying basis, speaks volumes. Special attention should also be called to the employment, in this station, of a great variety of lamps which enable satisfactory terms to be made by contract, on a basis of a guaranteed satisfactory light without specifying the units to be employed, which in such places as hotels, may be varied considerably.

DATA OF ECONOMY TESTS.

Date of test..........................Aug. 29 and 30, 1885.
Duration of test..............................12 hours.
Average boiler pressure..............................77.22 lbs.
Average temperature of feed water.........178.47° Fahr.
Average temperature of escaping gases....315.869° Fahr.
Average No. of ampères..........................689.6 ampères.
Average electrical horse-power............107.35 e. h. p.
Average No. of 10 c. p. lamps burning............1532.44.
No. of 10 c. p. lamps per indicated horse-power....10.63.
No. of 10 c. p. lamps per electrical horse-power.....14.28.

Character of fuel; Mixture of one part of Clearfield bituminous, price $2.21 per ton of 2,000 lbs. delivered, with three parts of anthracite screenings at 90 cents per ton of 2,000 lbs. delivered.

Amount of soft coal consumed..........................2,973 lbs.
Amount of screenings consumed..........................6,667 lbs.
Amount of wood was 600 lbs., equal in coal to....240 lbs.
Total amount of fuel consumed..........................6,980 lbs.
Percentage of moisture in coal..........................1.77 %
Dry coal consumed in test..........................9,705.124 lbs.
Total ashes and refuse..........................1,422 lbs.
Per cent. of ashes and refuse to fuel consumed.....14.6 %
Total combustible consumed..........................8,283.124 lbs.
Average dry coal consumed per hour..........808.76 lbs.
Total cost of fuel consumed..........................$6.47
Bituminous, $2.21 per ton..........................3.285.
Anthracite, $0.90 per ton..........................3.000.
Wood equivalent to coal at $1.55¼ per ton.......... .185.
Total..........................$6.470.

Total water actually evaporated under observed conditions..........................88,413 lbs.
Factor of evaporation.......................... 1.078
Equivalent evaporation from and at 212°.7885.7 lbs. per hr.
Water actually evaporated per lb. of dry coal...9.109 lbs.
Equivalent evaporation per lb. of combustible from and at 212° Fahr..........................11.42 lbs.
Equivalent evaporation per lb. of coal from and at 212° Fahr.......................... 6.749 lbs.
Commercial evaporation..........................8.2783 lbs.
Total heating surface..........................1,626 sq. ft.
Steam space..........................99.14 cu. ft.
Water space..........................236.66 cu. ft.
Area of grate surface, each boiler............37.43 sq. ft.
Area of chimney..........................1,661 sq. in.
Ratio of heating surface to grate surface.......43.44 to 1.
Ratio of grate surface to chimney area ....3.24 to 1.
Nominal horse-power rated at 11 sq. ft. of heating surface per horse-power ....147.8 h.p.
Dry coal actually consumed per hour per sq. ft. of grate surface..........................8.642 lbs.
Water evaporated per hour per sq. ft. grate surface from and at 212° Fahr..........................64.271 lbs.
Average dry coal consumed per indicated horse-power.......................... 5.61 lbs.
Area of heating surface.......1,626 sq. ft. in each boiler.
Pounds of water evaporated from and at 212° for $1 worth of fuel..........................14,625.72 lbs.
No. of candles per indicated horse-power......106.3 c. p.
No. of candles per electrical horse-power.......142. c. p.
No. of candles per hour for 1 cent's worth of fuel..........................284.31 c. p.
Cost of fuel per horse-power per year of 365 days of 12 hours each.......................... $8.92.

ABSTRACTS AND EXTRACTS.

THE TELEPHONE QUESTION.

To the Editor of the Scientific American:

I trust you will permit a brief summary in your columns of facts on the other side of the telephone question. They are as follows:

1. Reis telephones, when used *as described by him*, will not transmit speech.
2. He who invents a new *art* is entitled to the fame and financial success based upon a patent for such an art.
3. If the assertions that Reis *did* occasionally understand spoken words be true, that did not constitute the art of speaking, because an art is something that can be *controlled*, and Reis only spoke because the action of his transmitter occasionally was *beyond* his control.
4. Five years before Reis made his instruments, their principle was *fully published in a prominent scientific paper in the city where he then lived, under the name "telephony," and he was then an active member of the physical society of that place.* Those principles were first accurately expounded by Charles Bourseul, of whom said publication spoke.
5. The method of producing undulations by immersing an electrode in liquid, which is the subject of Mr. Gray's caveat, was described in Mr. Bell's original application, which was sworn to several weeks before Mr. Gray's caveat was *written*. Hence, it is absurd to assert that Mr. Bell obtained that idea from Mr. Gray's caveat.
6. That we can *now* speak with the Reis instruments is no more proof in favor of Reis than the fact that we can also *now* speak with a Morse key and sounder is a proof that Morse invented the art of speaking by electricity. Both, together with other electrical instruments, can to-day be manipulated on Bell's principles so as to transmit and receive speech.

E. BERLINER.

WASHINGTON, D. C., Nov. 27, 1885.

The statement made by our correspondent in his fifth paragraph, we believe, is now for the first time brought out, and is of especial interest in view of the testimony of Professor Gray.—EDITORS *Scientific American.*

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THE KEELEY MOTOR HUMBUG.

A Philadelphia capitalist states, according to a Washington letter, that if the true life of Keeley, the motor man, could be written, it would prove to be one of the most romantic stories of imposture ever known. He says that several years ago, when Keeley's great claims began to be talked about in Philadelphia, he made an investigation for his own satisfaction into Keeley's past. He thought that he could judge better by his record as a man than by trying to talk with Keeley about his mysterious motor. He found that just before coming to Philadelphia he was a performer in a circus, and that he had nearly all of his life made a precarious living by performing sleight-of-hand tricks. He is a man of no education, and is absolutely destitute of any scientific acquirement. He says that Keeley has gone to work, however, very skillfully, and has learned the jargon of an extensive scientific vocabulary. He has about 800 of these words and phrases at his tongue's end, and he can turn the head of the average scientist by the rapidity and certainty with which he tosses these words and phrases into his general conversation. Keeley has one gift, he says, which is great enough to be called genius, and that is his skill in humbugging people. He has great power, by mere talk, of setting aside all doubt as to his ability and to influence people to let him have money in the most recklessly confident way. Nearly all of his present backers are New York men. Every now and then these backers become despondent and get together and go over to Philadelphia. Then Mr. Keeley gets up a sleight-of-hand performance for them, talks to them in his peculiarly gifted way, and the trusting capitalists go back buoyed up with hope, fully confident that they are backing one of the great inventors of the age. Keeley has never invented anything, this gentleman says, except stories, and will never give any other dividend upon the capital invested in him beyond that of romance and diversions in the shape of occasional sleight-of-hand performances.—*American Railroad Journal.*

ELECTRICITY FOR STREET RAILWAYS.

The fourth annual convention of the American Street Railway Association was recently held at St. Louis. The following is an extract from the report of the committee upon the utilization of electricity for motive purposes:

"Your committee considers the application of electricity to the propulsion of street cars as entirely feasible. The seven electric railways in Europe, besides the tests in this country, prove this to be true. It is now narrowed down simply to a question of dollars and cents, or comparative economy with horses, cable power, etc. In the crowded streets of American cities no system of overhead wires would be permitted by the municipal authorities. The rails could not be used to carry the currents, for obvious reasons; therefore a conduit system offers the only practical solution. The system of running cars by accumulators can be applied with least trouble and less first cost, but at a great sacrifice of electricity. The result of two years' working of the electric railway at Zankerode, Prussia, showed that only 30 per cent. of the power of the steam engine was applicable to the propulsion of cars, but even this compares favorably with the cable system." In conclusion, a letter was read from a New York firm offering to equip any tramway with electric motors, and to stipulate that should satisfaction not be given the parties contracting, to move the same at the company's own cost.

EXPERIMENTS ON THE THICKNESS OF FIRES.

Mr. Thos. Richardson, M. A., and Mr. Lavington Fletcher say this concerning thick and thin fires: "The thickness of the fuel on the grates has proved to be an important element in the proper management of coal. We have tried 9-inch, 12-inch and 14-inch fires, and in all instances, whatever were the other conditions, the greater the thickness of the fires the more speed and power were obtained from the coals. To illustrate this we may add that a certain coal with 9-inch fires evaporated 9.779 lb. of water per pound of coal, at the rate of 48 cubic feet per hour, while the same coal with 14-inch fires evaporated 10.494 lb. at the rate of 53.3 cubic feet per hour. Other coal, with 9-inch fires, evaporated 10.236 lb. at the rate of 44.74 cubic feet, and with 14-inch fires, 11.057 lb. at the rate of 45.36 cubic feet per hour. It is sometimes assumed that with a small grate a thick fire must be carried, or the required quantity of coal cannot be burned in a given time; but this is only partially true. However, it is usually the case in practice that the smaller the grate the heavier the fire.

CAN UNDERGROUND HEAT BE UTILIZED?

In an article by J. Starkie Gardiner in the *Geological Magazine* for September, the above subject is presented with much novelty and interest. After describing the phenomena which proves that the earth's periphery is only a crust of solid matter floating on a molten mass, he asserts that this crust is more likely to be ten than fifty miles thick. He refers to the artesian well now being bored at Pesch, which has reached a depth of 951 metres, and states that the temperature of its water is now 161° Fah., and that the boring will continue till a temperature of 178° is reached. The obvious deduction is that the heat of the earth will ultimately be utilized by man in the place of costly fuel and furnaces. "It needs no seer," he says, "to pierce the not distant future, when we shall be driven to every expedient to discover modes of obtaining heat without the combustion of fuel, and the perhaps far remote future when we shall bore shafts down to the liquid layer and conduct our smelting operations at the pit's mouth."

THE HUMMING OF THE WIRES.

Mr. M'Bride, of Indiana, has come to the conclusion that the humming of telegraph and telephone wires is not caused by the wind. He has devoted a great deal of time and attention to the matter, and has found that the sound is more appreciable on a clear, calm evening than at any other time. He is also convinced that the effect is not due to electricity, for he could detect no signs of that agent when the humming was in full force, while at times when the wire was evidently carrying current there was no sound. Mr. M'Bride considers the question a subject of investigation which may lead to important discoveries. We consider that Mr. M'Bride is mistaken in both his deductions and his conclusion. The humming is set up by vibration which may be due to a number of simple causes, and transmitted from one point to another, even at a considerable distance.—*The Electrician* (London).

THE LIFE OF INCANDESCENT LAMPS.

Some of the Edison and Swan incandescent lamps, placed two and a half years ago on the Great Eastern Railway Company's steamer, "Norwich," running between Harwich and Antwerp, are still living. Though only guaranteed for 1,000 hours, they have lasted close upon 7,500 hours, for their light is on about 56 hours a week, and the steamer has only been fourteen days off the station. Although most have been replaced, so as to avoid the chance of their suddenly going out, two of the original lamps are retained in the saloon by way of curiosity, and their light is only a trifle less brilliant than that of the others.—*The Electrician* (London).

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CORRESPONDENCE.

NEW YORK AND VICINITY.

The Pilots Continue to Object to Arc Lamps.—The Board of Trade Wants the Telephone Companies Investigated.—Poles Erected in 42d Street.—Underground Gossip.—The Broadway Fire-alarm Boxes.—Curious False Alarms.—New Jersey Electric Lighting.—Wires Over the East River Bridge.—Striving to Cheapen Electric Lights on the Bowery.

SEVERAL months ago it was stated that the introduction of arc lamps along the streets bordering on the river was likely to prove an annoyance to pilots on account of their superior brilliancy which is in many cases objectionable. The East river ferry-boat pilots complain of the bridge lights as well, but as the ferry companies themselves are patrons of various electric systems they evidently do not consider that their use really adds to the dangers of navigation. The blinding effect of arc lights is really less serious than is generally supposed, and the obscuration of minor lights in their vicinity may be readily tested. It will be found that the supposed overpowering effect is to a considerable extent an illusion, the reason for not seeing the smaller light being because we insensibly, allow our eyes to be attracted by that which is most brilliant.

The Board of Trade in this city is composed largely of men who wish to make all the profits themselves, and feel that $12.50 per month for telephone service is a terrible burden upon the commercial interests of the city. Through Senator Reilly the board recently introduced into the legislature the following preamble and resolutions which was promptly tabled :

Whereas, The charge for telephone service in the city of New York has been raised since the consolidation of the various companies from $5 per month to $12.50, which is greatly in excess of the charges in other cities ; and the excuse given for this is the alleged greater expense per subscriber attending the service where a larger number of subscribers exist, and it is claimed that the telephone companies are not making excessive profits upon the actual capital invested; and

Whereas, It should be authoritatively ascertained whether or not this be true, so that if true the public may be satisfied and if not true that a combination of companies using the public streets and doing business by virtue of a public franchise, should not be allowed to use those privileges to unduly tax the public ;

Resolved, That a committee of three Senators be appointed with power to send for persons and papers and employ a stenographer, counsel and, if necessary, an accountant to investigate all the relations to the public of telephone companies doing business in the city of New York, and also how their charges, capital, earnings and dividends and service compare with those of other cities, said committee to report as early as possible during the present session by bill or otherwise, what, if any, legislation is needed to protect the public interest.

The wrath of Commissioner Squire was recently aroused by the erection of three large telephone poles on 42d street, without permission either from the department of public works or the Commission on Electrical Subways. A strenuous effort is being made by the city officials to prevent the erection of any more poles, but the wary lineman occasionally gets the best of them.

A despatch from Chicago to the *Times* published on Sunday, the 17th, aroused considerable interest by announcing that the New York commission had decided to adopt the Dorsett system for this city. The report was denied point blank through the press by all of the commissioners, who asserted with good reason, that the requirements of New York city were so different, and the undertaking of so much greater magnitude than in any other place, that nothing which they had seen could be adopted as a whole. The various rumors, probable and improbable, which are floating about town, are the necessary accompaniments of a decision which is believed to be of considerable financial importance.

The fire department has connected some of the Broadway boxes with the new circuits through the Western Union iron conduit between Dey and 23d streets. They have been tested, found satisfactory and can be relied on in the case of another great sleet storm such as thoroughly wrecked the wires a few years ago.

The keyless fire-alarm boxes which are now used are better adapted for posting letters than the old style which could not be so readily opened. When a lady has finally written and stamped a letter it must be posted at once at all hazards, and this is why the department was summoned a few days ago to the corner of Sixth avenue and 23d street. A lady with the urgent letter in hand opened the box, and followed the instructions by pulling the hook. When she finally discovered her mistake she did not wait for the arrival of the steamers and trucks, but walked rapidly away leaving the firemen to indulge in such remarks as they might deem proper for the occasion, without embarrassment from her presence.

In Passaic, N. J., a factory steam whistle serves as a fire-alarm. During the recent cold snap, it blew long and furiously about midnight. After a severe experience dragging their machines through the snow the firemen discovered that the long blast had been caused by the freezing of dripping water upon the valve cord, the weight finally becoming sufficient to turn on steam, and thus sound the alarm before the cause could be discovered. A fire-alarm telegraph to that point would now receive encouragement from the department.

Hoboken is rejoicing over the illumination produced by 45 new arc lamps in the streets, as well as many private lamps which add to the general effect.

Seventy citizens of Elizabeth, N. J., living on Morris avenue have pledged themselves to pay 50 cents each month to secure the substitution of electric for the naptha lamps with which that thoroughfare is now lighted. Such a movement proves that people are willing to pay more money for the sake of a better light, but it should be done through the proper authorities, for the reason that by the voluntary plan, a few decline payment while securing equal benefit with those who are willing to subscribe.

There are 292 wires across the East river bridge for each of which a rental of $30 yearly is exacted, excepting such as belong to the public departments of New York and Brooklyn. These will not be placed underground.

The Bowery has long been the most fertile field in New York city for private arc lighting. The dazzling brilliancy of the electric light early attracted the attention of its various tradesmen, and they appear to have been paying 75 cents per night for single lamps, which they are beginning to think is too dear. A movement is reported to be on foot which is at present enveloped in secrecy, to attain a substantial reduction in the prices of these lamps, which are mostly supplied by the Brush and United States companies.

It is not improbable that the scheme is being engineered by rival interests anxious to secure a foothold in the city. One of the most formidable obstacles to such an undertaking is the difficulty of securing street privileges in face of established underground legislation.

NEW YORK, Jan. 19, 1886.

PHILADELPHIA.

A Great Electrical Scheme on Foot.—Councils Striving to Ascertain When the Wires will be Buried.—Declaring New Poles a Nuisance.—Decrees Against the Overland Telephone Co.—Efforts to Suppress the "Bucket Shops."—A New Reporting Company.

ONE of the greatest capitalistic schemes that probably ever struck the city of Philadelphia, came to the surface of public affairs a few days ago, when there was a great rise in the stock of the American Sectional Underground Co. Although there was only a few shares sold, the advance was significant when taken in connection with the rumor that the two local companies operating under the leased privileges of the American company, viz : the Philadelphia Sectional Underground Co. and the Philadelphia Underground Electric Light and Power Co., had been sold out to a syndicate of Philadelphia capitalists, and that the underground system for furnishing light and power is to be extended over the entire city. But this project, great in itself, is supposed to be but a small part of the vast scheme which will embrace the burial of all the telephone and telegraph wires in the city underground, the manufacture and distribution of fuel gas to the city, and most probably in connection with the latter the purchase of the Philadelphia gas works. The money was paid several days ago and has been divided among the stockholders of the old company—that is, the Light and Power company. It has been reorganized and the stockholders have taken two-thirds of their interest out in stock in the new company and one-third in cash, so that the purchasers must hold at least one-third interest in the new company. The purchaser is understood to be William G. Warden, of Warden, Frew and Co., who represents the Standard Oil company in this matter. The price paid was $100,000.

The electrical committee of councils at a recent meeting discussed the subject of underground wires. The following is the substance of a letter read from president Green of the Western Union company, which was in answer to a communication from councils. It refers to the proposed action of the company in laying underground wires.

Desiring to meet all reasonable demands of the city of Philadelphia, this company would like to commence and complete putting all wires underground between the main office and Broad and Market streets and the principal branch office at Third and Chestnut streets, at the earliest period practicable. If the city authorities will give us permission to open the ditch on an eligible route for such purpose, without attaching thereto the onerous requirements to which objection was made in my communication to the mayor and councils respecting the last ordinance, we will commence the work in the coming spring as soon as the frost of the winter is sufficiently out of the ground, and complete it as rapidly as possible. We are willing the city shall place in our ditch, in form of cable or in separate tube, the city wires for their telephone, police and fire alarm service, not exceding twenty wires, in order that the city may fully test their success and will remove the overhead wires as soon as the success of the underground working is sufficiently established to render it safe to the public service to dispense with them. We have never thought it safe to rely solely on underground wires until they had worked succesfully for twelve months. But we shall be governed in a great measure by the judgment of your own city superintendent of electric wires, as to when he will feel that the lives and property of your citizens will be safe to rely on the wires underground, and shall take down the city lines on the opposite side of Market street from ours. We think it would be better for the city and for us to run the underground wires down Sansom, Walnut or Market streets, rather than down Chestnut, for reasons that will suggest themselves to the committee. We desire to place pneumatic tubes as well as insulated wires in our ditch. When the line proposed is completed and made a success, we can fix a period when we will undertake to extend the underground wires eastward to the Delaware and westward to the Schuylkill. Whilst this company is advised that it has the right to maintain its overhead wires, both under state and federal laws, we protest that we have not assumed a defiant position or shown any want of respect for orders of councils.

The letter then refers to Brooks' underground system and its

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failure to obtain authority to open the streets to lay its wires. It closes:

We protest against the injustice of denouncing us for not doing that which it has been impossible for us to do, and against the further injustice of singling out this company and ruling it to say what it proposes to do, whilst several rival telegraph companies, having more or less overhead wires, are left undisturbed and never complained of. Why are they not required to say what they propose doing?

Action on the letter was postponed until a future meeting.

The Baltimore and Ohio, Postal, and Bankers and Merchants telegraph companies and the Bell telephone company were requested to make answer why they have failed to bury their wires.

An ordinance offered by Mr. Etting, declaring the erection of all telegraph and telephone poles hereafter and those now standing, except for city purposes, a nuisance, the penalty for which is placed at $100 for each offense, was appropriately referred.

Final decrees have been entered in the United States circuit court in the suits of the American Bell Telephone company *et al.* against the Baxter Overland Telephone and Telegraph company, George W. Mears, Henry H. Mears, Francis Keyser, Morris H. Alberger, Daniel L. Hutchinson, C. E. Williams, and the Penn Overland Telephone and Telegraph company, Morris H. Alberger, Charles D. Middleton, E. C. Amer, F. H. Greene, and the Overland Telephone company, reading as follows:

This cause came on to be heard at the October term, 1885, of said court, and thereupon, and upon consideration thereof, it is found and hereby ordered, adjudged, and decreed, that the several letters patent upon which the suit is brought, viz:—Letters patent granted to Alexander Graham Bell for an improvement in telegraphy, dated March 7, 1876, and numbered 174,465; and letters patent granted to said Bell for an improvement in electric telegraph, numbered No. 186,787, and dated Jan. 30, 1877, are good and valid in law. That the said Alexander Graham Bell was the original and first inventor of the inventions described in said several letters patent Nos. 174,465 and 186,787; that the title thereto, and to the inventions described and claimed therein, are vested in the complainants, and that the defendants have infringed the fifth claim of said letters patent No. 174,465, and the third, fifth, sixth, seventh, and eighth claims of said letters patent No. 186,787, and the exclusive rights of the complainants under the same. And it is further ordered, adjudged, and decreed, the complainants waiving an account and assessment of profit and damages, and accepting a nominal sum therefor, that the defendants pay to the complainants the sum of $1 as such profit and damages, and also costs taxed at the sum of $25, and that the complainants have judgment and execution therefor; and also that the said defendants, and each of them, their, and each of their clerks, attorneys, agents, servants, and workmen, and all others acting under or with them, be perpetually enjoined and restrained from making, selling, or using the said improvements patented as aforesaid, or either of them, and that an injunction issue accordingly.

Strenuous measures taken by the Philadelphia stock exchange to exterminate the "bucket shop" brokers of Third street culminated a short time ago in a decree which promises to effectually accomplish the purpose. The operations of these offices are confined to small wagers, of from $10 to $50 on the rise or fall of stocks, and their customers constitute a class affected with the stock mania, who, by reason of limited means, are content to pursue the fickle goddess in the way best fashioned to their purse. The business is carried on among fifteen or twenty establishments in this city, which are dependent for quotations upon the tickers furnished by the Philadelphia local, and Bankers and Merchants' telegraph companies. The governing committee of the stock exchange served notice on both telegraph companies that unless they discontinued furnishing tape-line quotations to the bucket shops their privilege on the floor of the exchange would be rescinded. Meetings of the directors of both companies were called and prompt action in compliance with the request was taken. The Philadelphia local company notified its bucket shop subscribers that their use of the tickers would be discontinued after Saturday, January 16th. The Bankers and Merchants' company gave its subscribers three days' notice. The people who run the bucket shops, however, are inclined to be stubborn, and claim that inasmuch as the Philadelphia local and B. and M. companies are common carriers, they (the bucket shops) are entitled to all the benefits from the tickers that the stock exchange enjoys. It is understood that they intend going to law in regard to this matter.

Application for a charter has been made at the state department as follows: Electric Reporting Co., of Pennsylvania, with a capital of $5,000. This company, which will have its principal office in Philadelphia, is formed for the purpose of giving financial and general news and stock quotations by telegram in Philadelphia, Pittsburg, Oil City and Bradford. It will also maintain, lease and operate telegraph lines. The incorporators are George N Wakefield, William H. Smith, Jr., Charles H. Lang, Charles J. Lauderbach and Thomas R. Heller, all of Philadelphia.

The nominations for officers to be elected by the Franklin Institute January 20th, are as follows: President, Charles H. Banes; vice-président, Frederick Graff; secretary, William H. Wahl; treasurer, Samuel Sartain; auditor, William H. Cheyney; managers (eight to be chosen to serve three years), Persifor Frazer, William Helme, Edwin J. Houston, Enoch Lewis, William P. Tatham, William H. Thorne, John J. Weaver, William L. Boswell, George V. Cresson, William H. Greene, Charles H. Hutchinson, William D. Marks, Samuel R. Marshall.

PHILADELPHIA, PA., Jan. 19, 1886.

CHICAGO.

Improperly Located Arc-Lamps and Dynamos.—The Board of Trade Tower Lamps.—Reports of Fires Arising from Electric Light Wires.—Talk About Telephone Patents.—Professor Gray Seeks the Seclusion that his Cabin Grants.—General Rejoicing Among Would-be Telephone Promoters.

EVERYWHERE throughout the country there is a disposition on the part of electric light competitors to do two things: to put their lights high up, and get their dynamos and engines as far away from human ken as possible in the deep dismal sub-cellar, under side-walks, back of or beneath kitchens, laundries or any other abominable mess, as if any place was plenty good enough for an electric light plant or engine. Darkness may be overcome—except in the case of a system which a critic described as one where a candle was necessary to find the burning lights—but the dampness, the want of room and convenience, the lack of ventilation which are the accompaniments of too many plants which otherwise are commendable, are sources of constant and serious annoyances. The well-being of the plant is seriously affected by the former of these, while the health of the unfortunate who is compelled to spend the midnight hours in either a steamy or a dry atmosphere with the mercury at 110° to 120° is sure sooner or later to succumb to the deleterious effects of this heat and the impure air which is its universal accompaniment. A recent case of inspection will well illustrate these peculiarities so common to electric light plants. The measurements of a line which was presumed to be in first class condition, showed that the insulation was far below what it should be for an arc plant. The line was divided at a point as near the centre as was practicable, and the two portions showed about the same amount of leak. The cable was at once accused, but to prove or disprove this, a test for cross was made, and a leak established between the two branches—what appeared to be an impossibility, except on the assumption of poor cable insulation. After considerable head scratching and a generous ventilating of theories, it was suggested that possibly the fault might be nearer home. To make a long story short, the dynamo room, in which are both the engine and boiler, had been run with underwriter's wire, on porcelain insulators, and both wire and insulators were covered with condensed moisture, which accounted for both the leak and the cross. The trouble was entirely cleared by substituting water-proof cable for underwriter's wire.

The placing lights as high as possible has its last and most perfect exemplification at the Board of Trade building in this city. When this building was first completed, Mr. E. A. Sperry purposed, if properly encouraged, to place a crown or wreath of arc lights around the top of the tower, which would serve as a beacon light from afar—a sort of label so to speak—telling strangers wandering hitherward in the dark nights of our northern clime the name of the settlement they were approaching. The matter remained in abeyance, until about the middle of December, and on the last day of the departing year, at 5.30, all being in readiness, a lady friend of, and at a signal from, the young inventor, turned the switch, and the crown broke out in a brilliant glare of light and beauty which brought round after round of cheers from the people in the deep shade of the building. The corona consists of 20 Sperry lamps attached to an iron ring encompassing the upper portion of the tower, over 300 feet from the pavement. This ring is of four inch gas pipe, and weighs nearly a ton. Four arms at the top of the tower support it through pulleys and ¾ inch steel cables, running inward to the tower and thence downward to a drum and windlass by which the huge circle of lights is raised and lowered. The wires pass out of the tower at a point midway between the upper and lower limits of the ring's travel, so that these are held taut, whether the lamps are lowered for trimming, or raised for burning. The insulation of the lights from the ring and thus from the building was considered a difficult task, but Mr. S. accomplished this in a most perfect and ingenious manner, the measurement showing an insulation which is practically infinity. The success of the scheme, as far as lighting at a distance is concerned, is perfect. The lights have been seen across the lake at Michigan city, and also at the mouth of the St. Joseph river in Michigan. A contract by which the plant is to run nightly for a period of three years contains guarantees from both the company and the parties who will pay for the light, the Board of Trade people furnish the power, the company a man to attend the dynamo, responsible parties put up the necessary funds, and the public puts up its hands in token of its admiration.

From all over the country, as the annual reports of the various municipal departments are published, we hear rehearsed the story of the dangers of electric lighting. In the words of a rural poet, in his annual New Year's address—

"From ev'ry point we hear the cry of fire,
And learn 'twas caused by an electric wire.
Forthwith the people's voices loud resound:
'To arms! to arms! and put them underground.'"

New Orleans, Louisville, Omaha, Peoria, East Saginaw, Cleveland, Boston—all these cities have had more or less experience in this line during the past year; and in the mildest manner possi-

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ble it is proper to remark, they are like the razor-strop man, liable to have "a few more left of the same sort," until the wires are placed where they will attend strictly to their own knitting, and let other people's wires and property alone.

The recommendation of the secretary of the interior has waked up all the anti-Bell people, and all the wonderful facts which have been paraded heretofore, during the many trials of the past five years, are again town talk. Parties are interviewed, and their wise saws and modern sentences are recorded in the daily papers with as much unction as if these were now for the first time unearthed for the benefit of a long suffering and ill at ease community. According to one of these sensational writers, after simmering down the article, the day is not far distant when two things will be accomplished: The Bell monopoly will be broken up by the annulling of his patents—because the Reis invention preceded them, and the invention will then become the property of all telephone men—and the patent will be given to Gray, who was defrauded by Bell.

The depth of this sort of newspaper logic is something "no other fellar can find out." It comes pretty near a piece of electrical mathematics which was published in the interests of a new battery, recently: "Electro-motive force, 1.6 volts; intensity of current, 5¼ ampères; internal resistance, 7-100 ohms (!) with the battery on short circuit."

Doctors disagree as to the final outcome of the matter. The *Tribune* of the 16th has several interviews with prominent opponents of the Bell company. Mr. A. C. Story, attorney for the Inter-State company, says:

"I felt like throwing my hat in the air when I read the despatches in the *Tribune* announcing Mr. Lamar's decision. It means, I think, death to the Bell monopoly, for I believe to-day, as I have always believed, that Bell obtained his patent through fraud and through collusion with dishonest employés of the patent office. It is a well-known fact that upon the same day and some hours before Bell filed his specifications in the patent office, Prof. Elisha Gray, of this city, had filed a caveat of his specifications, and it is my firm belief that Bell in some manner surreptitiously obtained possession of Gray's papers and made use of them to further his own ends. A significant fact, and one that goes far toward supporting my theory in this connection, is that within a very short time after Bell's patent had been granted and the company organized, two patent examiners in the employ of the department at that time resigned their positions with the government and were given positions with the Bell Telephone Co. at salaries of $25,000 a year or more. But to go beyond this: There are many reasons which go to show that Bell or any one else had no right to lay claim to an invention for the transmission of sounds by any electrical agency. A man might as well apply for a patent which would give him the sole right to produce force by means of a current of air. Long before Bell, or Gray either, for that matter, had thought of such a thing as a telephone, or had ever uttered the word, Philipp Reis, of Germany, had almost succeeded in the construction of such an instrument."

"How soon do you think the government will commence proceedings?"

"Right away. The decision of secretary Lamar will go before the President, and the latter will doubtless at once place it in the hands of the attorney-general, with instructions to proceed. Once the machinery of the government is set to work in the matter it will proceed rapidly—too rapidly, I imagine, for the comfort of Bell and his associates."

"Prof. Elisha Gray, who, it is claimed, is the real inventor of the telephone and whose caveat for the same was filed in the patent office at Washington before Bell's application was filed there, as referred to in secretary Lamar's decision, is a resident of Highland Park, one of Chicago's suburbs, and has an office in this city. He put in an appearance at this office only for a few minutes in the forenoon of yesterday, and then did not care to see reporters. His secretary refused to reveal his whereabouts. He was holding conferences with his friends, he explained, and could not be seen during the day. Prof. Gray did not return to his home by either the 5 or 6 o'clock train, and his assistant secretary, Mr. Cushing, admitted that he did not do so in order to avoid the reporters. From friends of Prof. Gray it was learned that while the decision of secretary Lamar was gratifying to him (Gray) as a scientific man, yet he would have preferred, perhaps, that he would be permitted to take entire charge of the case to establish his own rights as patentee and inventor. He did not like that phase of the decision which left the initiative in the matter to the attorney-general, and which practically excluded him from participation. One friend said that did not give the case a pleasant financial aspect. This suggested the idea that Prof. Gray might have an idea of compromising the case if his financial interests were safely guarded. His friend was questioned concerning this, but refused to answer. He merely shrugged his shoulders."

The owners of opposition or outside stocks are said to be arranging a jubilee hymn, to be sung when the dead certainty of a glorious smash-up of the Bell monopoly is fully assured. Rumor has it that one verse of this effort will run as follows, after Dr. Watts:

"And are we sinners still alive,
And do we still rebel?
'Twas grace amazing, grace divine,
That busted up the Bell."

CHICAGO, January 17, 1886.

BOSTON.

Interest in Secretary Lamar's Opinion.—Depression of Telephone Stock.—A Dividend Declared by the New England Telephone Co.—Preferred Stock Proposed for Issue.—Legislative Interference in Electrical Affairs.—Local Railway Projects.—Electric Storm Signals.—Edison Incandescent Street Lighting.—The Schaefer Electric System.—An Embezzling Telephone Manager.—Another Electrical Lecturer.—Henry K. Goodwin Convicted of Murder in the Second Degree.

THE electrical excitement for the last few days has been the decision of secretary Lamar against the American Bell Telephone Co. ordering suit to be begun in the United States courts testing the validity of the patent issued to Alex. Graham Bell, which has been the bulwark of the company upon so many well-fought and victorious legal battle-fields. It was almost a foregone conclusion in the minds of interested Boston people, but yet there was a surprise due to disappointment when the news arrived. All who had read the arguments of Messrs. Storrow and Dickerson were convinced that the Bell people had the rights of the matter, but the situation in Washington has been so complex that all hopes of a decision founded on law and evidence was given over. This is the hardest blow that industries founded on patents have ever received in this country, and a most surprising thing in all of the controversy has been the apparent apathy of the people so interested outside of the telephonic field. One would naturally suppose such an attack would have been intensely and personally interesting to those who have millions invested in business enterprises founded on patents.

The news of Secretary Lamar's decision was quickly known at the brokers' board, and as was natural, the Bell stock fell sharply off, opening at 165, a drop of seven points from last sale of the previous day, the stock sold down to 160 closing at 160½, the following day it fell below 160. This is not so bad a drop as occurred some two years ago when the news was received that the Philadelphia suit would be hung up pending the decison of the People's—Drawbaugh case in New York, which shows that the Lamar decision had been well discounted

The next telephonic item is the announcement of a dividend by the New England Telephone and Telegraph Co., of ¾ of 1 per cent quarterly, and the statement that a committee of three from said company had met with the directors of the American Bell company and agreed upon a plan whereby the long waiting stockholders could begin to receive something for their invested money. The president of the New England company, Mr. Thomas Sherwin, has issued a call for a special meeting of the stockholders at their office 144 Greenwich street, New York, on February 2d at eleven o'clock, for the following purposes.

1st. To consider and act upon the question of authorizing and issuing preferred stock, not to exceed one million of dollars, in ten thousand shares to be issued as needed for construction or purchase of plant.

2d. To consider and act upon the plan for the modification of the contract with the American Bell Telephone Co., in the matter of waiver of dividends recommended by the directors. The stock of the New England company made a rapid advance and sold at 38 and 38¼, but suffered with the main company under Lamar's Washington remarks, and run down to 34 and 35

Our legislature is now in session and the little orders relating to electrical matters have begun to spring up, to blossom later on. In this connection a Mr. Lilly, who was so prominent an opponent of telephone interests last year, has prepared an act this year for the regulation of telegraph and telephone companies doing business in the state.

A Lowell despatch to one of the Boston papers says that an agitation is to be begun at once all over the state to obtain legislation limiting the rentals to be charged by the American Bell Telephone Co. to licensed companies and by licensed companies to subscribers. Legislation will also be asked to tax the Bell company more equitably and fully than at present.

The elevated railroad people are getting ready for a warm campaign. Mr. Bowman has been at the State House, with the intent of getting his petition started charter-ward as soon as possible. He appears to mean business, although it is claimed by some that the Somerville syndicate have but one object in view, to wit, to sell out at the most favorable terms obtainable. There is one significant fact in regard to the elevated road problem, namely, that the third house is favorable to the Candler company, the most portentous of the several enterprises before the legislature. The Candler people evidently mean business, at least so far as getting a charter is concerned.

A meeting was held last week of several property owners who are interested in securing some legislation to provide a solution of Boston's puzzle, to consider the various methods proposed outside of elevated railway systems. The use of electric motors was discussed at some length, and letters were read from the managers and presidents of the companies using this motive power, speaking of it in terms of unqualified commendation. Estimates were also presented, showing the cost of equipping such a road and of changing a horse road to this form.

The plan of underground railways, which is now agitating railway circles and the public in New York, and will soon come before the legislature at Albany, received very careful attention. The proposed system was explained in detail and the estimated cost of construction was considered with reference to this city. The general plan found great favor with the gentlemen present, though the great expense of the undertaking was regarded as a possible disadvantage. It was argued, however, that the enterprise would surely pay a good interest upon the investment, and that New York capitalists stood ready to back such an enterprise here if Boston capital was too timid, providing the necessary charter could be obtained. The plan was discussed at considerable length, and the meeting adjourned until a future time, when the general subject will be further discussed.

Whenever it is necessary to display storm signals at night at

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the signal service station in Boston, the lanterns are lighted by electric lights, which make them remarkably brilliant. This is the only station in the country at which electric lights are used for the signals.

On Dec. 24th last the streets of Lawrence, Mass. were lighted for the first time with the Edison incandescent light. The lights which are placed on high poles, are of 16 c. p. in the principal streets, and 10 c. p. in other places.

A new incandescent lighting system was demonstrated in Cambridge on the 14th inst., the inventor being a young German named Frederick Schaefer. There has been organized, under the laws of Maine, a stock company for the purpose of carrying on the business of lighting by electricity. The inventions have all been patented in this country, Canada, Mexico and Europe, and are entirely novel as compared with other systems. This exhibition was the first to which outsiders have been admitted. The most noteworthy feature of the new invention is that the carbonized filament in the incandescent lamp is composed primarily of a simple silk thread, which, when carbonized, remains as flexible as platinum wire. These filaments, the inventor claims, have been tested to last for over two thousand consecutive hours. Another peculiar feature is that one hundred thousand of these filaments can be prepared in ten hours, and the cost of their preparation is trifling. Each lamp has a brilliancy of from fifteen to thirty candles, and a two-horse power engine will drive a dynamo to a minimum capacity for furnishing thirty lamps. In this exhibition 250 lamps were maintained by a dynamo propelled by a 16 h. p. engine the light being white and of great brilliancy. The organization is known as the Schaefer Electric Manufacturing Co., and has a capital stock of $150,000, with power to increase the same. The officers are—president, L. Schlegelmilch; secretary and treasurer, Werner Malsch; directors, L. Schlegelmilch, Henry P. Veith, Ferdinand Schaefer, Peter Schell and Frederick Schaefer, the latter being the electrician of the concern. The inventor has a laboratory at Cambridgeport.

Charles B. Perkins, ex-manager of the Holyoke Telephone Exchange, was arrested in Springfield on the 10th inst., by deputy sheriff Ham on a charge of embezzlement and grand larceny, preferred by the New England Telephone Co. Since his discharge Jan. 1, when office expenses had to be reduced, a collector found many subscribers who showed him receipts that were not entered on the books. The company's auditor has been investigating the matter, together with division superintendent Daball. Perkins had been missing, but returned very quietly Saturday, and after some trouble was found and arrested. He had nothing to say for himself, and no cause is assigned for his actions.

Geo. H. Hartwell lectured on "Civilized Electricity" at the rooms of the Mercantile Library Association on the evening of the 16th inst. The lecture was illustrated by novel experiments and numerous stereopticon views.

In the case of Goodwin who shot Swan some months ago—all the parties being connected with the Molecular Telephone Co.—after the charge of the judge, the jury returned a verdict of murder in the second degree, after being out six hours.

Boston, Jan. 18. 1886.

WASHINGTON.

The Purport of the Various Government Telegraph Bills.—The Modified Military Telegraphers' Bill Likely to Pass.—Suggestions that Congress Proceed to Try Some Telegraph Plan.

In my last I mentioned the fact that a number of bills looking to the establishment of a postal or government system of telegraph had been introduced in both branches of congress. The bills were then inaccessible, the originals being in the hands of the public printer. Mr. Edmunds was the first with his senate bill of last year to establish as a basis for the system, by construction outright of four trunk lines from Washington, running north-east, north-west, west and south-west, the branches to be added from time to time as congress may order and make appropriations therefor, the whole being a part of the postal system. The acquisition, construction and repair of the lines is placed in the hands of the secretary of war, the practical operations under the postmaster-general, these two officers and the secretary of state to form a board for the location of the trunk lines and the general outline of the project. Two million dollars are appropriated to begin the work. Clerks, electricians and operators, are to be appointed under civil service rules, the higher and lower offices being left for payment for political services.

The closing section provides that the act shall not prohibit individuals or corporations from carrying on the business of operating telegraph lines. The seventh section of the bill authorizes the secretary of war to "take and use all such machinery, appliances, devices and materials, not including telegraph lines owned by persons or corporations, whether patented or not as shall be necessary for the convenient and successful establishment and operation of said lines" giving the owner recourse to the court of claims in case of disagreement as to indemnification. This clause of course covers the use of the duplex and quadruplex patents.

Senator Cullom's bill is in detail the same as that of senator Edmunds. He, however, proposes that under the act of July 24, 1866, the postal telegraph commission (same as in the Edmunds bill) shall acquire by purchase any existing line shown to the satisfaction of the commission to have earned a revenue equal to expenses necessarily incurred in its maintenance, reconstruction and operation for the 12 months prior to the passage of the act. The purchase of such lines is limited to $1,000 for each $50 net earnings during the aforesaid 12 months. Payment is to be made in 3 per cent. 30-year bonds at not less than par. An indefinite extension of these lines at the discretion of the postmaster-general is authorized by the Cullom bill.

Representative Rogers, of Arkansas, was the first to start the ball in the house wing. He has a bill "to secure cheaper telegraphic correspondence." He starts out by declaring all post-offices in places where there is telegraphic service, and such others as the postmaster-general may designate, postal telegraph offices. He then fixes a tariff of rates for business other than that of the government, to be paid in stamps. The rates fixed are 25 cents for 20 words or less for less than 1500 miles. For each 250 miles, additional five cents more, and one-fifth of the charge to be added for each five words above 20. Double rates insure the sender a copy repeated back and notice of delivery or non-delivery, no rate to exceed 50 cents for 20 words. Night rates are fixed at one-half day rates as above.

Telegrams between New York, Philadelphia, Boston, Baltimore and Washington, and such other points separated by short distances as the postmaster-general may designate, are to be sent for 15 cents day or night. These rates cover ordinary delivery within letter carrier limits, special delivery charges for long distances to be fixed by the postmaster-general. Press matter is to pay 35 cents per 100 words at night and 75 cents during the day. Drop copies 25 night, 50 day. Extra manifold copies, five cents per 100 words. Money-order telegrams to the extent of $100 are also provided for.

The receiving and delivery of messages, with office and battery rooms, etc., are to be provided by the post-office department. For the telegraphic service, that is the transmission of the matter, the postmaster-general is authorized to contract with any telegraph company owning 1,000 miles of wire for the performance of such service at or under the above rates, less three cents for each message to be retained by the government as its share of the tolls.

Mr. Weaver, the Iowa greenbacker, goes into the business in no half-way manner, although his bill declares its object to be to establish a postal telegraph that shall ultimately reach every post-office in the United States.

He creates the office of fourth assistant postmaster-general and makes that officer the director of the telegraph, and appropriates $25,000,000 for the construction and equipment of lines to be commenced simultaneously or as nearly so as practicable at Portland, Me., Seattle, Wash. Ter., Boston, Mass., Portland, Oregon, New York, Philadelphia, Baltimore, Washington, Richmond, and so on to Galveston and in like manner at some 15 or 20 points between Cleveland, O. and San Diego, Cal., and vigorously pushed until every town in the United States of 400 inhabitants and upwards is supplied with postal telegraphic facilities. With characteristic regard for the general public Mr. Weaver fixes a uniform rate of 10 cents for 10 words and five cents for each five or less words added.

The support of his bill by the press is assured by the rate of tolls on press matter, which is but 25 cents per 100 words. Another commendable feature is the issue of telegraphic cards, with ten and fifteen stamps, with blocks for as many words as the stamp will carry so that any one can write his message and drop it in the nearest post-box. But the great feature of the bill is a proviso that any deficiency in the receipts of an office to pay operators and messengers shall be made good out of the original appropriation of $25,000,000.

Mr. McCombs of Maryland proposes in his bill to contract for service, to purchase or to construct the lines and operate them at government expense, at a charge of one cent a word, counting date, address and signature, with a sliding scale after the first 100 for the press. The sum appropriated to carry out the scheme is modestly left blank. Civil service examination is required for clerks, electricians and operators. Mr. Bingham, ex-postmaster of Philadelphia, stands sponsor for the Edmunds bill in the house, he having introduced it there.

Mr. Anderson, of Kansas, reintroduces his old bill for three trunk lines as follows: from Bangor, Me., via Boston, Albany, Buffalo, Cleveland, Fort Wayne, Chicago and Madison to St. Paul; from New York via Philadelphia, Pittsburg, Columbus, Indianapolis, St. Louis and Kansas City to Topeka; from Baltimore via the seaboard route to San Antonio, Texas. Numerous lateral branches and intermediate stations are also indicated. Six million dollars are to be applied to the construction of these lines. The present military lines and lines accepting the act of July 1, 1866 and other railroad charters are to be utilized as far as practicable. His rates are uniform at 30 cents for 10 words and three each added word.

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The bill for the relief of army telegraphers, which was first introduced two years ago, has been reintroduced by senator Logan and representatives Wait, of Conn., and Dunham, of Ill., this year. As originally introduced it proposed to confer rank, and in several other ways was so framed as to make its execution impracticable after the lapse of so many years, and after frequent conferences with secretary Lincoln and officers of the army and department it was amended so as to declare the members of the United States military service entitled, as a part of the army in the war of the rebellion, to the rights of homestead entry and pensions, the rate of pensions for cryptograph and other operators and master-builders to be governed by that of commissioned officers of equal pay, all others to rate as privates. The secretary of war is to have medals prepared at the Philadelphia mint for operators and master-builders, and deliver to them or their legal representatives a certificate of honorable discharge, stating term and character of service, etc. There is a good chance for the passage of the modified bill.

This embraces all the telegraphic legislation thus far proposed. The practical portion of your readers will doubtless be amused with the several schemes proposed. It has been suggested that these various propositions may serve to bring the attention of congress to the subject, and lead to some practical test by the lease or purchase of existing lines before going heavily into untried paths. Of any developments in this direction the readers of the ELECTRICIAN AND ELECTRICAL ENGINEER shall be promptly informed.

WASHINGTON, D. C., Jan. 23, 1886.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICIAN AND ELECTRICAL ENGINEER, 115 *Nassau Street, New York city.*

THE ELEVATED RAILWAY PROBLEM.

[46].—In a letter in your last issue, by Mr. Frank J. Sprague, whom we all know to be an enthusiast on electric railways, after making some contemptuous observations on my "corrected figures," which would be very objectionable were they not so obviously unfair and uncalled for as to be amusing, he says that I lost sight in my calculation of the grades of the elevated roads, and that the work done by the locomotives is expended in three ways, one of which is lifting the train up the grades, which, he says, is about 24 per cent. of the whole work.

The mistake of not allowing for the inertia of the train in the first article I printed would have been a good one not to make; though this criticism might perhaps sound better coming from me, as the same mistake had entered into all previous estimates, and I was the first to discover it and point it out. But it will stand comparison favorably with the mistake of supposing that any material power of the locomotives in a complete trip is consumed in lifting the train up the grades. So long as the grades do not exceed a certain amount, it makes no material difference what the total ascent is, provided the train at the end of its trip lands at the same level as that from which it started.

In ascending a grade, gravity retards, and additional power is of course required proportional to the slope; but in descending to the same level again, gravity assists, and you have the benefit, throughout the descent, of the *potential energy of position* which has been acquired in the ascent by elevating the train to a higher level, and which enables the train to descend with just as much less power from the locomotive as it had to exert more power in ascending. And it does not make any difference (except, of course, in respect to the brakes) when and how often you stop, for while the train is descending, or when it is starting, it always has the assistance of gravity corresponding to the grade.

Mr. Sinclair, in the July *Car Builder*, seems to have been under the same erroneous impression, though it did not affect his results, for he says: "There is less than one mile of level track on the whole line, and engines pulling trains do not here, as on a surface undulatory road, receive the benefits of the momentum gained going down a hill to help the train up a succeeding grade, for the stops are so frequent that all benefit from that source is lost." Of course, if the train stops at the bottom of the hill or anywhere in the descent, it loses the moving energy due to the speed acquired by reason of its change of level; but while descending the hill you have the benefit at every point of gravity which assists the train either in starting on the hill or in maintaining the speed, an amount in the aggregate equal to its retarding effect in an equal ascent. Consequently as much less steam is required in the descent as was required more steam in the ascent.

This must be true of any grade, so long as the slope does not exceed that at which the train will descend by its own gravity without steam, which would be its *angle of friction*, or more accurately, the angle corresponding to its coefficient of traction, taken at the maximum running speed, in which case the effect of gravity would be just enough to produce the maximum speed without any steam being used. In a case where the grade was of exactly this slope, just double the power would be required to ascend that would be necessary to maintain the same speed on a level grade, while the locomotive would have to exert no power in descending, so that the average power of the locomotive throughout the trip would be the same as if the track had been a level one.

When the grade exceeds this amount, so that the tendency of gravity alone is to force the train down the hill more rapidly than is allowable, then obviously the full benefit of gravity which cost so much additional power in the ascent, can not be realized in the descent, and there is a loss to just that extent.

As there are no such grades on the elevated railroads, Mr. Sprague is entirely wrong that any such amount as 24 per cent. of the locomotive power is expended in lifting the train, or that any amount sufficiently large to be worth considering in this calculation is so expended.

Mr. Sprague further says that "my agreement with Mr. Sinclair is purely accidental, caused by getting the average maximum speed too high, leaving out the work of lifting and the element of engine or motor friction."

The average maximum speed which I took was 23 miles an hour, which I estimated from several different sources, and is two miles an hour less than that given approximately by Mr. Sinclair in the July *Car Builder*.

Mr. Sprague says that the average net horse-power is about 69, and that only 59 per cent. of this, or about 40 h. p., is spent in overcoming inertia. If that were so, and the weight of the average train were about 80 tons, which is what I took and what Mr. Sinclair says it is, the maximum speed must be in the neighborhood of only 19 miles an hour, which is only four miles greater than what Mr. Sprague gives as the mean running speed, and is, therefore, obviously too low.

As regards the accuracy of the figures. in giving the results of my calculation in both the last papers, I took care to give the result at the round figure of 75 h. p., leaving out any decimals in the larger numbers, in order to indicate that the data and consequently the result were only approximate, and nobody reading those papers with any sort of fairness could have inferred that any further accuracy was implied than what naturally followed from a correct basis of calculation, the result of which was not several hundred per cent. out, as all previous calculations had made it.

Mr. Sprague says that some forthcoming papers will answer my query, how and why the roads are to be operated by electricity. I never propounded any such question. What I asked was, how each effective horse-power on the track was to be obtained with less or materially less than 6.6 pounds of coal per hour.

As to the practical advantages of electricity over steam, that is entirely another matter, that cannot be gone into here, and I have no doubt that the method which Mr. Sprague is following of putting a separate motor in each car, is much the best way of doing it. CHARLES G. CURTIS.

UNDERGROUND TELEPHONE WIRES.

[47].—Referring to letter (44) printed on page 32 of the January number of the ELECTRICIAN AND ELECTRICAL ENGINEER, I find that a gentleman claiming me for his friend, and signing himself "H. C. Frempt, Sup't Brooks Underground Conduit Co.," freely criticises a statement made in the course of my last instalment of the series of articles written for that journal upon "The Construction of Lines for Electric Circuits."

Although the gentleman courteously styles me his friend, I cannot say that personally I am acquainted with him; for, as a matter of fact, the only time prior to this that I have heard of or seen his name, was in a communication made in October, 1884, to one of the Philadelphia daily papers, which communication gave a garbled and in many respects a false report of remarks made by myself, and of comments upon the said remarks made by Mr. Preece before the conference of electricians. I did at that time ascribe the animus of that letter to interested motives, to be explained by the title following the signature. The letter now under consideration supplies a good reason for a modification of that opinion; and I am now, I think, justified in ascribing the general character of the last letter (and perhaps the first also) simply to a lack of knowledge of the subject. It is implied in the letter of Mr. Frempt, although not distinctly stated, that it is because I am connected with the American Bell Telephone Co. that I have written the paragraph which he quotes; for even conceding the truth of his assertion that I "do not want the wires to be buried because it costs a little more than stringing them on housetops" (which concession I most decidedly do not make), it is of course absurd to suppose that my alleged predilections are personal, and the inference is unavoidable that they

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are due to the aforesaid connection with the aforesaid company.

If the friendship expressed by Mr. Frempt were based upon personal acquaintance, he would know that I am the very last person in the world to publish or make statements from interested motives or because they are supposed or may be supposed to be in accordance with the views of other persons, or of corporations with whom I may have business relations, or to publish any statements whatsoever unless they are my own sentiments, based upon both study of the subject and practice.

A careful and analytical contemplation of the technical statements contained in Mr. Frempt's letter fails to show anything which runs counter to the text which he has taken from my remarks upon underground wires.

I am quite of the opinion that the circumstances which he details concerning the visit of the New York commissioners may be entirely correct, but this admission neither proves nor disproves, or in fact affects in any way, the statement I made.

I will here, for facility of reference, repeat the statement which is so objectionable to Supt. Frempt of the Brooks Underground Conduit Co. It is, that "wires centering at telephonic exchanges are not conveniently placed underground, as the retardation due to static induction shows itself on very short lines, and makes the talking very indistinct. This is quite perceptible even on a half mile line, and is much emphasized when a long line is connected thereto."

It is to be observed that there is not a word in the above statement relative to the results or effects of voltaic, electro-dynamic, or magnetic induction; but it is equally to be observed, that the communication of Mr. Frempt deals with dynamic induction only, and contains no statement regarding electrostatic induction, to which the adverse phenomena of retardation and prolongation are entirely due.

This seems to show that there is no distinction between the two inductions in the mind of Mr. Frempt.

It is of course true that a telephone metallic circuit, when the out and return wires are so placed as to be equidistant from the source of disturbance, is silent; even though currents are passing, of continuous and intense variation, in closely adjacent circuits. But as between underground and overhead wires, this proves nothing; for the same metallic circuit arranged in the same way is equally silent whether underground or overhead. Surely no one will undertake to prove that such a metallic circuit is free from noise due to induction *because* it is underground.

Rather does it prove the other fact, that in addition to the effects of static induction (for which, by the way, the parallel return metallic circuit is not an efficient remedy), dynamic induction is so apparent in the underground wire that the metallic and parallel return circuit is necessary to avoid it. This view certainly meets the first part of my original statement exactly; for who will undertake to prove that it is "*convenient*" to have 2,500 or 3,000 metallic circuits entering a central office?

It is asserted that I have made statements in violation of facts. It is respectfully submitted that I, employé of a telephone company, though I be, have had some chance to compare the work of telephone wires overhead with similar wires underground, and that the opinion of one experienced in such comparisons with respect to the relative clearness of the transmitted and reproduced sounds, and the amount of retardation developed, is at least of equal value with that given as the result of one or two tests by the New York commission, by electrical experts traveling with them, or by a specialist who has an underground conduit to sell or to bring into use.

No impartial electrician worthy of the name, can deny that retardation due to static induction between the wire and the earth is plainly discernable in short underground telephone wires, as in all fast systems when laid underground.

As to the latter part of my statement, that the retardation or sluggishness is emphasized when a long line is connected to the underground line, this is an equally well-known phenomenon to experienced telegraph or telephone electricians.

Its recurrence even on the automatic systems of telegraphy—which for speed of variation are as nothing compared to telephonic currents—has for years been a matter of observation, and is described in many text books; for example, "Telegraphy," by Preece and Sivewright, pp. 125 to 128, edition of 1880; "Handbook of Practical Telegraphy," Culley, pp. 410–411, 7th edition; "Electricity and the Electric Telegraph," vol. ii., pp. 709–10, 6th edition; and many others.

This statement is also the result of actual experience. With respect to the implication that the American Bell Telephone Co. does not wish to bury wires, because it is a little more expensive in first cost so to do, it is sufficient answer to say, first, that the American Bell Telephone Co. has no city wires of its own; and in the second place, that it is notorious that of all the local telephone companies of the United States, it is those controlled by the American Bell Telephone Co. that have most extensively laid down underground wires, *inconvenient* though it be to do so; and I may cite as examples Boston, Pittsburg, Chicago and Washington.

It does not seem to me that I could have worded my slight and simple reference to underground wires more modestly. It certainly was no more intended as an attempt to influence the New York commission than it was to prove a red rag to the zeal of a superintendent of an underground conduit company. Perhaps it would have shown more judgment on the part of Mr. Frempt had he permitted my statement to pass unchallenged, unless some person not interested in underground conduits chose to challenge it.

THOMAS D. LOCKWOOD.

BOSTON, January 2, 1886.

TESTS ON INCANDESCENT LAMPS AT THE FRANKLIN INSTITUTE.

[48]—It was not our intention to take any notice of the published results of the Franklin Institute tests on incandescent lamps, as considering the very strong complaints that had been made on the subject in the various electrical journals, we thought it most unlikely that anyone would be misled by them. We have however been advised that unscrupulous persons—more especially on the continent—have been taking advantage of these tests to disparage our lamps. We shall therefore be glad if you will allow us the opportunity of emphatically denying that any reliance is to be placed in them, and of placing before your readers the following facts. We were advised by our agent in America to have nothing to do with the tests, as they would not be reliable—the Swan, Maxim, and other makers of incandescent lamps having refused to allow their lamps to be entered—we accordingly decided not to compete. Lamps, however, stated to be ours, were entered without our knowledge or consent—half being actually supplied by the Edison company, the chief competitors, and the rest were obtained from another electric lighting firm. Whilst being admittedly run at 5 volts above what they were labeled, giving out up to 40 per cent. or 50 per cent. above the proper candle-power, they were placed in competition with lamps evidently most carefully made and tested beforehand. As an example of the way in which the electrical press have treated the tests, we may call attention to the *Electrical Review*, of America, dated June 13th, in which are given verbatim reports of interviews with the president and secretary of the Institute, the latter stating he refused to have anything to do with the incandescent lamp tests because he did not believe in them. Another official of the Institute stated some three months ago that it was very doubtful if the tests could be seen by outsiders, as the tests themselves did not agree. Whilst in many instances disagreeing with the methods adopted in the actual tests, we refrain from criticising them, as we are well aware of the many difficulties that have to be contended with. We merely add that we think the Institute ought to have seen that we were properly protected and advised of what was going on. We are glad to hear that there is some chance of complete tests being made in this country, when every precaution will be taken to insure their being properly made.

WOODHOUSE AND RAWSON.

LONDON, December 21, 1885.

QUESTIONS AND ANSWERS.

[72.]—**Siemens and Halske battery.—Siemens unit.**—H. E. P., inquires: 1. How is a Siemens and Halske battery made? 2. What is the E. M. F. of each cell? 3. How does a Siemens unit of resistance compare with the ohm? Ans.—1. It is a modification of the Daniell battery, in which a flat copper plate is placed at the bottom of the jar. The porous cup is bell-shaped at the bottom, and is placed over the copper, the connecting wire running up through the tubular upper portion of the porous cup. The sulphate of copper is introduced into the top of this cup. On the outside of the bell-shaped lower portion of the cup, and between it and the outside jar is packed a mass of paper pulp, up to half the height of the cell. This pulp has been dampened with sulphuric acid and then dried. A thick, cylindrical zinc is placed on top of the pulp. This has a vertical arm for a connection. Like all batteries of this class it is charged with water. 2. The electromotive force is less than a volt., the external resistance being high. 3. A Siemens unit is 0.9536 of an ohm.

LITERATURE.

REVIEWS.

Manual of Telegraphy, by W. WILLIAMS, Superintendent Indian Government Telegraphs, 327 pp. 8° (*illustr*). London: Longmans, Green & Co.; New York: D. Van Nostrand. Price $4.20.

The fact that this manual was written to order by the Director-General of Telegraphs in India, and that its object is the instruction of the staff, intimates that it should be a practical work. A superficial glance at its contents proves that such is the case, and while the character of the service upon which it is based is such that much of the information is not applicable to the

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American telegraph systems, it contains sufficient matter of a general character to render it a valuable text-book even in this country. The work is divided into six sections, section A embraces electrical and magnetic definitions; section B, telegraph batteries; section C, signaling instruments; section D, telegraphic circuits; section E, faults in circuits and their remedy; section F, testing. In an appendix are grouped the laws of currents, of circuits, and of induction, also various formulæ and their solutions, with tables of sines and tangents.

The section devoted to batteries is very complete, and gives not only comprehensive instruction as to their care, but the principles which govern their action. The various types of battery with which our readers are familiar are described, the preference in the Indian service however being in favor of the Minotti form, which is essentially the same as the ordinary gravity cell, the sulphate of copper being, however, surmounted with a diaphragm of river sand or saw-dust. Each of these materials has its advantages the choice being governed by circumstances. In the climate of India it might at times be easier to gather sand than saw wood, while if the saw-dust was at hand there would be no occasion for a trip to the Ganges. On account of the time required to bring new cells into working condition, a reserve force is usually kept on hand, from which the zincs are removed (to avoid waste from local action) to be replaced as required.

The Fuller battery has been used to some extent, but is considered as less convenient, and at the same time more expensive than the Minotti. The great advantages of the latter are summed up as being due to the constancy of its E M. F. which remains the same from the time the battery comes into action until it is exhausted. It does not depend upon the strength of acid solutions, and the hydrogen generated by the action of the battery, which is the great enemy to constancy when in its free or uncombined state, by virtue of its polarizing effects, is prevented from remaining free by its immediately combining, by chemical affinity, with the sulphate of copper solution, and taking the place of a certain amount of copper which it reduces from the solution, depositing it on the copper plate immersed therein, the plate being thus continually supplied with a fresh bright copper coating, as long as the action of the battery continues.

Thirty ohm sounders being generally used, four local cells in series are necessary to the best effect. A standard cell is kept in every office as a unit of E. M. F., being prepared with special care and used only for testing.

The Siemens polarized relay is universally adopted for departmental use, but it appears not to be wholly satisfactory excepting for *double current* working on account of the small margin for proper adjustment. The efficiency of a relay is tested by its range obtained by the following rule.

"Adjust the relay with minimum play, with the tongue as "far from the metallic stud as regular working will admit of, so "that it will work with one cell through a resistance equal to its "own; then apply 10 cells without any external resistance; the "relay should work without readjustment, thus displaying a "range of 20, the minimum range a Siemens relay should "exhibit."

The Siemens Morse sounder is generally used, constructed upon the same principle as the American sounder, but of a less elegant pattern, and with apparently less attention to its sound producing qualities. Repeating points appear to be considered as essential to a complete sounder. The armatures are of thin iron plate, bent cylindrically, the edges not joining. The following rather elaborate directions are given for proper adjustment of the spiral spring.

"Adjust the spiral spring by the following process: work the "sounder electrically and tighten the spring until the magnet is "unable to attract the armature; mark the position of the screw "on the stem; now loosen the spring until the armature falls on "the electro magnet by its own weight; mark the second "position on the screw, then tighten the screw to about midway "between the two marks. N. B. Fix all jam-nuts securely."

Two other forms of sounders are shown—the Douglas and the Dubirn. The former is similar to those used in this country previous to the advent of the pony sounder. The lever is pivoted in the centre like a walking beam, with a sounding post at each end, one for the direct, the other for the back stroke. The Dubirn sounder is designed to utilize the strongest magnetic field. The magnet is placed with its poles downward and resting on the base, they being extended beyond the helices for a sufficient distance to permit the armature to play between them, it being centered on a pivot midway between the coils. One end of the prolonged armature acts as the sounding part, its excursion being limited by appropriate screws fixed to the base of the instrument.

The portable sounder is a polarized instrument of a pattern which would not find favor with those who are accustomed to the very compact and serviceable outfits produced by American manufacturers, for transportation in the pocket.

Various forms of signaling keys are shown, a description of the discharging key leading up to a very clear explanation of the effects of static induction, upon a well insulated line, to obviate the effects of which a transmitting device of this character is essential for the purpose of clearing the line between signals. The author says:

"Induction is the main cause which diminishes the speed of "signaling; first, by accumulating on the surface of the wire a "portion of the current which would otherwise pass on to form "signals; the quantity accumulated depending upon the length "and surface of the wire, upon its proximity to the earth, and "upon the insulating medium which separates it from the earth. "For this reason the electro-static capacity of cables is much "greater than that of land lines—*i. e.*, they hold a much greater "charge. The greater this electro-static capacity, the less the "speed, for it causes the first portion of a sent current to be ab-"sorbed or accumulated as shown above, and thus it retards the "first appearance of the signal at the distant end. Again, at the "cessation of the signal the accumulated charge takes an appre-"ciable time to discharge, and consequently each signal is pro-"longed. Thus 'charge' *produces retardation, and 'discharge' "prolongation.*"

The various common forms of galvanometers, and their applications are set forth under the head of testing instruments.

Section C, devoted to magneto electric instruments, embraces the telephone, and as naturally associated with it, the microphone transmitter.

A very complete table of electrical symbols for use in diagrams is given in the space allotted to telegraphic circuits. The open circuit system is generally used in India for the departmental wires, while the closed circuit is used on the state railway lines. The principal duplex circuits are worked on the double current differential system. The bridge and split battery duplex systems are fully described, also Gerrit Smith's battery reverser, and all are more or less used in the Indian service.

For office connections Hooper's india-rubber covered wire is given preference over gutta-percha, and it is advised that every joint should be soldered excepting the terminals at binding screws, which should be kept scrupulously clean.

The development and removal of faults is a most important part of successful telegraphic administration, and in this respect the author has performed a most important duty in pointing out the various ills to which the most perfect electrical system is continually subjected. The electrical and mechanical faults encountered are similar to those which worry the wire chief wherever he may be located.

The last section of the manual gives various methods of testing in all its branches. The peculiar character of the Indian service requires that particular attention be given to the regular testing of the lines, in order that any departure from the normal condition of the circuits may be at once detected and electrically located. The Wheatstone bridge is universally used for this work.

In the appendix are given the laws of currents, circuits, electro magnetism, induction and magnetism, which are convenient of access, and therefore add to the value of the book as one of practical utility in the field for which it has been especially prepared.

The general arrangement of the subject matter with its side notes, marginal titles and cross references is very commendable, and no electrician will fail to appreciate the merits of this "Manual of Telegraphy" by merely glancing over its pages.

ACKNOWLEDGEMENTS.

While calendars are not showered upon the public in such profusion as they were at one time, those which are now distributed are artistic and consequently beautiful.

That which has been issued for 1886 by Alfred F. Moore, of Philadelphia, the well-known manufacturer of insulated wire, is made up of twelve elegantly lithographed cards, of designs befitting the months which they represent, and is the very creditable production of a Philadelphia house. It is to be regretted that the edition is already exhausted.

Eugene F. Phillips, president of the American Electrical Works, Providence, R. I., has also kindly sent greetings of the new year to his numerous friends in the form of a handsome calendar, embellished with an attractive engraving, which is universally admired, and is given a prominent location as an ornament to more than one editorial sanctum.

NEW PERIODICALS.

Modern Light is the title of a new monthly journal published at Boston, in the interests of electric lighting, gas and petroleum lighting and heating. It is well arranged, neatly printed and apparently conducted upon the very sound principle of justice to all. Nothing can be more certain than that there are extensive fields for all classes of artificial illumination not excepting the modest tallow dip.

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ELECTRICAL NEWS AND NOTES.

THE GOVERNMENT TO TEST THE VALIDITY OF THE BELL TELEPHONE PATENT.

OPINION OF SECRETARY LAMAR.

The secretary of the interior has addressed the following communication to acting attorney-general Goode:

DEPARTMENT OF THE INTERIOR,
WASHINGTON, Jan. 14, 1886.

SIR: I have under consideration the papers referred to me from the department of justice touching the Bell telephone patents. Desiring to be as fully advised as possible, I have called to my aid the assistant secretaries of the department and the commissioner of patents. In furtherance of the same desire I have invited the parties who filed their petitions with you, and also the parties interested in the patent which is assailed, to appear before me with such proofs and arguments as they might desire to submit. A voluminous record and a prolonged and exhaustive discussion resulted. This record, embracing all the papers sent to me from your department, and also the printed arguments of counsel, I transmit herewith.

The petitioners, upon the grounds and for the reasons set forth in their petitions, ask the department of justice to cause or allow appropriate legal proceedings to be instituted in the proper court by the government or in the name of the government on their relation to vacate and annul the Bell telephone patent of the 7th of March, 1876, in the petitions specified. You have asked me to communicate any information on the subject to be gathered from the files of this department, and to suggest generally my views as to the action which should be taken by your department in the premises. As the patent office appertains to this department, I have been especially desirous to understand fully all that is alleged as ground for relief in these petitions in regard to what was done in that office, and I believe I can assure you that all the information on that subject to be gathered from the files of the office is embodied in the record herewith transmitted. I also send you the views of the commissioner and of assistant secretaries Muldrow and Jenks respectively.

In order to know what suggestions I should make as to the action of your department upon these petitions, I have heard the oral presentations of the case, and considered it again upon the proof and the able arguments of counsel as they appear in print. I thought that my own consideration should be directed to two questions, and to meet these questions I requested that the arguments of counsel should be shaped. They are:

First—Has the government the right to institute such a suit for such a purpose?

Second—If it has such right, should the proceedings invited in the respective petitions, or either of them, be instituted?

The first of these questions, specifically within the cognizance of your department as it is, was the affirmative answer of numerous precedents in that department, and has received a like affirmative answer from the courts of the United States. If it had not been thus authoritatively settled, I should, on principle, have reached the same conclusion. The government is asked to institute judicial inquiries as to the patent of the Bell Telephone Co., upon the allegation that such patent was obtained by the fraud of the patentee, with the collusion or by the inadvertence and mistake of the executive officers of the government. If these allegations be true, a great wrong to the whole people rests in the name, and is sustained by the power, of the United States. To say that the government inflicts the wrong would seem to imply that somewhere among its resources the government would have the power to redress it. The argument against the prayer of the petitioners does not controvert this, but rests upon the theory that the government has provided a remedy which excludes all other modes and, therefore, precludes further governmental action. By a review of the patent acts of Congress it is sought to be shown that, under the law of 1790. somewhat modified in 1793, the citizen was allowed to avail himself of all legal objections to the patent in defense of infringement suits, and, under certain circumstances, the court was allowed to institute, *scire facias*, an inquiry into the validity of patents, and upon cause found, to vacate them. By the act of 1836, which is the only other legislation material to this inquiry, it is claimed that the patent law was changed by the establishment of a patent office charged with the duty of investigating the claims of applicants, and clothed with the power (formerly exercised by any two cabinet officers) to issue patents, and that from this law the *scire facias* section and so much of the defense section as allowed the court to vacate a defeated patent, were omitted. Hence it is argued that by the act of 1836 all power to vacate a patent was surrendered, and all remedy when a patent had wrongfully issued was limited to a reliance upon the faults or vices of the patents in defense of actions for infringement. Without the aid of decisions made by the courts it would seem to be apparent that the only office of these legislative changes, made in 1836, was to deprive the courts of the power to vacate patents as an incident to private suits or as a part of the judicial determination of private controversion. The power of the government to vacate patents, wrongfully issued under its seal, was affirmed in the very act of intrusting its exercise to the courts in private litigation. The logical inference from the revocation of that trust is not a total surrender or abnegation of the power, but the intention to keep it under immediate governmental control. The existence of the power implies the possible occasion for its exercise. The legislation which allowed the courts to exercise it defines what circumstances in the view of congress would make the occasion; and the changes made by the law of 1836 only seem to indicate that the existence of the occasion shall be brought to the notice of the proper department of the government, and the exercise of the power invoked.

Surely, if the power to vacate a patent wrongfully issued exists at all, there need not be a statute to provide a mode of its exercise when a mode exists without a statute. A patent for land may, for good cause in a proper case, be vacated at the suit of the government, without a statute, and there is no difference as to the principles here involved between a patent for land and a patent for an invention. The public domain is held by the government as part of its trust. The government is charged with the duty and clothed with the power to protect it from trespass, and, under circumstances, to invest the individual by its patent with the sole possession of the title and rights before appertaining to all as the beneficiaries in the trust. If two patents for the same land should issue to different individuals, at least one of them would be wrongful. In such case, the title having rightfully passed to one, it may very properly be left to the individuals to settle by private litigation the question of right, in which they alone are interested. One of the patents must be void, and the establishment in court of the validity of one must of necessity settle finally the character of the other. If it should come to the knowledge of the department that a patent has been fraudulently obtained, and the fraudulent patent is the only one issued for that land, then there would be an occasion which would make it the duty of the government to exercise its right to have the patent vacated, because private litigation cannot arise and because the rights of all the people would be involved without other mode of redress.

The inventor is the sole owner of his invention, but to publish it, by use or otherwise, is to give it to the world. The rights which would then accrue to the whole people from such publication are confided as part of the general trust to the government, with the power by its patent to create for the inventor a monopoly in the use of his invention. This patent, just as does the patent to the land, shuts out all the world except the patentee from the use and enjoyment of the subject of the patent. If two patents issue for the same invention, one is certainly wrongful. If the other is rightful, the whole interest in the question as to which is rightful, is confined to the two patentees, and private litigation will secure the needed remedy in determining who has the right to the patent as between rival claimants. If, however, there is only one patent, and it has been fraudulently obtained to the exclusion of the one really entitled to be patentee, or if a patent has issued for something not patentable—an invention already belonging to the world—it becomes the duty as well as the right of the government, when of sufficient public importance, to actively seek its cancellation, because private litigation is not a possible or adequate remedy, and because the whole people are wronged, without other mode of redress.

Under our government a trust can never fail for want of a trustee, nor can fraud, mistake or accident in business transactions escape investigation for want of a tribunal while the court of equity is maintained. Representing the sovereign in his person in the mother country, that court also represents the sovereignty here in a sense and relation of nearness which no other representative can claim. All the other agents are recognized as amenable to judgment upon the strict letter of their commissions and acting at the peril of having their action disapproved and set aside. But a court of equity, specially adapted in jurisdiction and methods to supplement statutory jurisprudence, is the depository of the reserved or not expressly delegated judicial power; it especially has the inherent jurisdiction to cancel and vacate what exists as the creation of fraud, accident, or mistake, and to faithfully apply the remedy for a maladministered trust. If a patent ought to be vacated it can always be vacated there; but the patent bears the great seal of the government. and only the government even there can ask to have the seal torn off.

My second inquiry was as to whether the right of the government existing, the proceedings invited by these petitions, or by either of them, ought to be instituted. The grounds of invalidity alleged against the Bell telephone patent may be substantially summarized thus:

First—The patent was procured by the fraud of the patentee through the collusion or mistake of the officers of the patent office, and in violation of the rights of a caveator named Elisha Gray.

Second—The invention patented was not patentable, because already public. Referring to what I have said under the other

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head of inquiry, it is apparent that these allegations describe the occasions in which the government, upon my view, ought to actively interfere for the cancellation of a patent.

It is manifest that a decision upon the merits of the controversy, as to the validity of the patent, is not embraced within the terms of your request. The issue before me lies outside of the ultimate merits of the case as a subject of judicial investigation. As to what the final judgment should be, I have not felt called upon to form, and if I had formed I would not express an opinion. The question is whether enough has been shown upon the hearing to require the submission of the matter to the court at the instance of the government. The proof adduced in support and defense is very voluminous, and very conflicting in many respects. It involves great scientific research and detail, and perhaps some intricate legal questions. The allegations and the evidence touching the circumstances attending the issue of the patent are of such a nature and have such a support as to render it, in my opinion, improper to ignore or dismiss them. Such a case is presented as, I think, ought to undergo thorough judicial investigation. It appears that many suits have been pending and many are now pending between the corporation claiming this patent and others that assail it. In none of these cases has there been, or can there be, as I think, such thorough investigation and full adjudication as to the alleged frauds or mistakes occurring in the patent office in the issuance of the patent, as could be had in a proceeding instituted and carried on by the government itself. In a case involving such questions, it seems to me especially imperative upon the government, as duty to its own officers to vindicate or condemn, and duty to the people to set on foot and follow up a complete investigation. In my opinion, the proceeding should be in the name and wholly by the government, not on the relation or for the benefit of all or any of the petitioners, but in the interest of the government and the people, and wholly at the expense and under the conduct and control of the government. I think it should be instituted at such point and in such court as will best subserve the purposes of public convenience and full inquiry. Such a proceeding, so conducted, will, as I think, comport with the dignity of the government and the gravity of the subject, and will insure a final and just adjudication of the merits of the controversy.

Very respectfully, L. Q. C. LAMAR.

The Hon. JOHN GOODE,

Acting attorney-general, department of justice.

THE STATE LAW ESTABLISHING THE COMMISSION OF ELECTRICAL SUB-WAYS.

An Act providing for placing electrical conductors underground in cities of this state and for commissioners of electrical sub-ways.

Passed June 13, 1885; three-fifths being present.

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

SECTION 1. Within twenty days after the passage of this act in any city of this state having, according to the last census, a population exceeding five hundred thousand and less than one million, the mayor of such city is hereby authorized and directed to appoint, and in cities having a population exceeding one million, the mayor, comptroller and commissioner of public works of such cities are hereby authorized and directed to appoint three disinterested persons, residents of the respective cities for which they shall be appointed to be a board of commissioners of electrical sub-ways. Such board shall meet as soon as practicable after such appointment, and shall then organize by the election from their number of a president and a secretary of the board. The board shall give at least ten days' notice, in a daily paper published in such city, of the time and place of such meeting.

§ 2. The said board of commissioners is hereby charged with the responsibility of enforcing the provisions of an act entitled "An act in relation to telegraph and electric light companies in cities of this state," passed June fourteenth eighteen hundred and eighty-four as amended; and the said act is hereby amended and made to conform in all respects to the provisions of this act, and it is hereby made the duty of said board of commissioners to cause to be removed from the surface and put, maintained and operated underground wherever practicable all electrical wires or cables used or to be used in the business of any such company in any street, avenue or other highway in any such city, so as to enable and require all duly authorized companies operating or intending to operate electrical conductors in any street, avenue or highway, of any such city as is or shall be affected by the provisions of said act, to transact their business with underground conductors wherever practicable.

§ 3. When any company, operating or intending to operate electrical conductors in any such city, shall desire or be required to place its conductors or any of them underground in any of the streets, avenues or other highway of any such city, and for that purpose to remove the same from the surface thereof, and shall have been duly authorized to do so, it shall be obligatory upon such company to file with said board of commissioners a map or maps, made to scale, showing the streets or avenues or other highways which are desired to be used for such purpose, and giving the general location, dimensions and course of the underground conduits desired to be constructed. Before any such conduits shall be constructed, it shall be necessary to obtain the approval by said board of said plan of construction so proposed by such company; and said board has and shall have power to require that the work of removal and of constructing every such system of underground conductors shall be done according to such plan so approved, subject at all times to such modifications as shall from time to time by the board be made, and subject also to the rules and regulations, not inconsistent herewith, prescribed or to be prescribed by the local authorities having control of such streets, avenues or other highways of such city.

§ 4. It shall be the duty of said board of commissioners to carefully investigate any and all methods proposed by such company for electric lighting or electrical communication by the use of conductors along or across any street, avenue or other highway in any such city; and, before approving of any such method, said board of commissioners shall require that, so far as practicable, all such conductors when constructed shall be underground; provided no suitable plan is proposed or in use, within sixty days after the passage of this act, it shall be the duty of such board to cause to be devised and made ready for use such a general plan as will meet the requirements of said act and of this act, and the board shall have full authority to compel all companies operating electric wires to use such sub-way so prepared in accordance with the provisions of this act. Wherever, in the suburbs or along the streets, avenues or other highways in sparsely inhabited or unoccupied portions of any such city, the public interests do not require the electrical conductors to be placed underground; and wherever, in any other locality of any such city, it is deemed by said board to be for any cause impracticable to construct and successfully operate underground the electrical conductors required by any such company; then, and in either of those cases, it shall be the duty of said board of commissioners to examine and grant the application of any such company for permission to deviate there from an underground system; but the board shall not grant any such permission unless the board shall be satisfied, upon investigation, that such a permit should and for one or the other of the reasons hereinbefore stated, be in such case granted and that it will not interfere with the successful working of underground conductors elsewhere in such city. Any such permit shall be held and construed to authorize the construction and maintenance of the lines of conductors therein provided for, as and where prescribed by the board. It is hereby made the duty of said board of commissioners in granting any such permit for other than underground electrical connections, to bear in mind the policy and purpose of this act, which is to convert the overhead systems of electrical wires and cables now in use in said cities to underground systems as soon as possible without impairing the efficiency of their service to require that, as far as practicable, all electrical conductors in any street, avenue or other highway of any such city shall be removed from the surface and placed and operated underground, as soon as may be consistent with the convenient use thereof by the public; and that it is intended hereby to authorize other than underground electrical conductors, to be used in the streets, avenues or other highways of any such city only when and where the public interests do not require the electrical conductors to be placed underground, or when and where it shall be deemed by the board itself to be impracticable to place and operate the conductors advantageously underground as aforesaid; and that it is hereby intended to make all aerial or other electrical connections incidental only to such underground methods, and to require that they be authorized only when and where needed for the convenient use of the public, or where the underground conductors can be made thereby more useful. The work of constructing every line of conductors authorized by any such permit, so granted, shall be subject to the rules and regulations, not inconsistent herewith, prescribed or to be prescribed by the local authorities having control of such streets, avenues and other highways in such city; every such permit shall specify the location of the structures to be erected and to be used for sustaining the electrical conductors, and shall give the general dimensions thereof; and a copy of every such permit shall be filed by said board of commissioners in the office of the mayor of such city, to which it relates, and shall be recorded there in a book to be provided and kept for that purpose, which shall be at all times accessible to the public. It shall be the duty of said board in devising the aforesaid plan so to devise the same that the subway may be used by any such city for the electric wires or conductors operated by its police, fire or other departments without expense except the expense of the wires or conductors, but no such city shall be compelled to place any such wires or conductors underground until the money has been specifically raised therefor by the proper authorities and until that time any such city may continue to use and extend such wires in the same manner as though this act and the act referred to in the second section of this act had not been passed.

§ 5. Whenever said board of commissioners, in carrying out the provisions of said act, shall permit any aerial electrical wires or cables to be carried along or across and above the surface of

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any of the streets, avenues or other highways of any such city to be crossed by aerial electrical wires or cables, it shall be the duty of the board to designate also, in such permit, the route and location thereof, and to prescribe and regulate the height at which such wires or cables shall be placed; and it is hereby expressly provided that when any such permit shall be granted by said board of commissioners, in extending the connections of any subterranean electrical conductors for the erection of any structure or structures for sustaining electrical conductors above the surface of any highway, or for placing wires or cables on any such structure or elsewhere than underground, or for carrying any such wires or cables across or along and above the surface of any highway or for placing wires or cables on any such structure or elsewhere than underground, or for carrying any such wires or cables across or along and above the surface of any highway or over or into or in the rear of any building or block in any such city, any and all such structures, and any and all such wires or cables, shall be so erected and maintained as not to incommode the other public uses of such streets, avenues or other highways.

§ 6. The term of office of said commissioners shall expire on the first day of November, eighteen hundred and eighty-seven, or sooner upon the performance of their functions, as herein prescribed. Each of the commissioners so to be appointed, and each of his successors in office, is and shall be removable for cause, but only upon notice and after an opportunity to be heard, by the governor of this state, who has and shall have power to fill any and all vacancies, however caused, in the office of either of the commissioners hereabove named.

§ 7. The salary of each of said commissioners and of every successor of either of them, if appointed for either of such cities having a population of more than one million, shall be five thousand dollars per annum, and if appointed for either of such cities having a population of less than one million shall be three thousand dollars per annum, payable quarterly by the comptroller of this state, who shall also audit and pay quarterly all necessary and incidental expenses of such boards of commissioners[1] the amount of such salaries and expenses shall be by the comptroller assessed upon and collected from the several companies operating electrical conductors in any such city of the state, which under the provisions of said act are or shall be required to place and operate any of their conductors underground, and the amount of any such assessment shall be paid by the company upon which it is so assessed to the comptroller in instalments quarterly or oftener as when required by him.

§ 8. It shall be the duty of every such company to furnish the comptroller, from time to time, as and when requested, all data by him desired, to enable him to apportion the relative share to be paid by each such company of the expenses of said board and of the salaries of said two commissioners, such estimate to be by the comptroller made with reference to the number of miles of wires operated within the limits of any such city, and the several companies interested to be by the comptroller assessed ratably according to the number of miles of such wires, which the comptroller shall certify to be operated by them respectively.

§ 9. All maps, books and papers of said board of commissioners relative to electrical conductors in any such city shall, at the expiration of the term of office of such commissioners, be filed in the office of the mayor of such city and shall be there kept at all times accessible to the public.

§ 10. All acts and parts of acts inconsistent herewith are hereby repealed.

§ 11. This act shall take effect immediately.

STATE OF NEW YORK, }
Office of Secretary of State, } *ss.:*

I have compared the preceding with the original law on file in this office, and do hereby certify that the same is a correct transcript therefrom and of the whole of said original law.

JOSEPH B. CARR,
Secretary of State.

CORPORATION TAXES—DEFECTS OF THE UNDERGROUND LAW.

The annual report of state comptroller Chapin contains matters of special interest to electrical companies in New York state. Referring to the taxes on corporations, he says that the effect of recent legislation, as well as of judicial decisions, has been to wipe out nearly all resistance to this tax. The case of the Western Union Telegraph Co. is, however, a notable exception. The efforts of that corporation since 1880 to evade the payment of its state taxes are recited, and the fact that a judgment for $179,371 was procured by the state against the company in the fall of 1883 and affirmed by the court of appeals in 1885, is recalled. The comptroller remarks:

The amount due upon the judgment is at present about $132,000. It is not possible, under the code of civil procedure in its present form, to assist an execution against a domestic corporation by supplementary proceedings, either during the pendency of such execution or after its return. In this respect such corporations enjoy an immunity which is not accorded to private individuals. **Perhaps it is just that they should enjoy such immunity, but it is not right that** such exemption should operate to the prejudice of the people of the state that grants the franchise. I therefore submit herewith to your honorable body an amendment to the code of civil procedure (schedule 19) which should be speedily passed, and which will give the right in all actions where the people are plaintiffs to resort to supplementary proceedings after judgment has been rendered and execution issued. This judgment should be paid. Justice to the numerous corporations which complied with the law, while this company was seeking to evade it, demands such payment. The interests of the public treasury demand such payment. The good faith of the stipulation demands it. What has been here said of the Western Union Telegraph Co. applies to the Gold and Stock Telegraph Co., against which corporation the claim of the state is much smaller.

Among other acts which need perfecting is chapter 499 of the laws of 1885, which provides for placing electrical conductors underground in cities of more than 500,000 population, and which also provides for a commission. Under this act the commissioners are to receive salaries, and their expenses are to be paid by the comptroller of the state. On this subject Mr. Chapin says:

There is no appropriation in the bill, and, furthermore, although the comptroller is authorized to assess and collect from the various telegraph, telephone, and other electrical companies the amount of the salaries and expenses, no sufficient power is conferred upon him, nor is any penalty imposed upon the companies for non-compliance with the law or with any demand that the comptroller may make upon them. The commissioners' salaries and expenses, therefore, cannot be, and have not been paid, because certain companies, among them the Western Union, refuse to make returns of their mileage, upon which return any assessment must necssarily be based. This department will not pay such salaries and expenses out of the public treasury. Unless, therefore, your honorable body so amends this law as to make the salaries and expenses of the commission payable out of the proceeds of an assessment upon the companies, at the same time providing for the collection of such an assessment, the prospect is that the law will be entirely ineffectual. The act was passed ostensibly to carry out the provisions of chapter 534 of the laws of 1884, which provided that the wires of such companies should be placed underground before November 1, 1885, in cities having a population of over 500,000. Whether the policy indicated in these two laws shall prevail or be abandoned is not for this department to determine. But it is the duty of this department, as well as of your honorable body, to see to it that this imperfect legislation be not made a basis for claims against the state for services not rendered to the state.

THE DAFT MOTORS IN MARYLAND.

The use of electric motors on the Baltimore and Hampden railroad has been so satisfactory that two additional machines have been added, making four in all. The first two, named the Morse and Faraday, weighed about 4,500 pounds each, and were rated at 10 h. p. The new motors, the Ohm and the J. L. Keck, weigh 5,000 pounds, and are called 20 h. p. The power is supplied by an engine developing about 75 h. p., driving two Daft dynamos which supply the current to the third rail. The consumption of coal is about 1½ tons per day. The motor Morse averages a run of 75 miles per day, and has run over 1,000 miles without requiring any repairs. Two of them take the place of 30 horses Superintendent Robbins is so well satisfied with his experience thus far in the use of electricity for street railways, that he intends next spring to equip the Catonsville road with a similar outfit.

THE GRAY TELEPHONE COMPANY.

Referring to the new telephone company incorporated at Springfield, Ill., January 16, Prof. Elisha Gray's attorney says:

"It will be a Chicago enterprise, and the headquarters will be there. The object is to protect Prof. Gray and prosecute his case. The capital is $10,000,000, and the commissioners are Elisha Gray, N. B. Judah, and N. E. Swartwout. The organization will be perfected without delay. The local company will be very nicely situated to carry on business, as Prof. Gray and his associates own the underground conduit already in, and it will not take long to put in a complete telephone system. Sub-companies will be organized throughout the country on the same general plan as those now in existence. Whatever results from this controversy the people cannot help being greatly benefited by getting a better service at a cheaper price. I take it that the people of this country would be perfectly willing to have the man who has made the laws of nature flexible to his will, receive not only the praise and the honor but financial results from such a magnificent invention. In short, we intend to prosecute Prof. Gray's rights through to a final adjudication, if necessary before the supreme court of the United States, and we have ample capital to do it with."

"If you open exchanges in Chicago," was asked, "and elsewhere, will not the Bell people apply for injunctions?"

"It is the opinion of eminent attorneys that, in view of the pending suit on the part of the government to test the validity of the Bell patents, the United States court would not interfere if bonds were given. We haven't the slightest fear of the outcome."

ANNUAL MEETING OF THE UNITED PRESS.

The annual meeting of the shareholders in the United Press was held January 13, at the St. James Hotel, New York city. The directors' report showed that the business of the association had been largely increased during the year, the earnings having reached $250,000. The treasurer's report showed a handsome surplus on hand to the credit of the shareholders. The following

1. So in original.

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officers were elected: President, Charles H. Taylor, the Boston *Globe*; vice-president, John H. Farrell, the Albany *Press and Knickerbocker*; treasurer, C. R. Baldwin, the Waterbury *American*; and secretary, Walter P. Phillips. The board of directors is as follows: Charles H. Taylor, John H. Farrell, C. R. Baldwin, Walter P. Phillips, James W. Scott, William L. Brown, Robert S. Davis, W. C. Bryant, James E. Scripps, Arthur Jenkins, E. H. Butler, Samuel D. Lee, and Samuel S. Blood.

THE COMMERCIAL CABLE COMPANY.

The general manager of the Mackay-Bennett cables reminds the patrons of that popular line that December 24th was the first anniversary of its opening for business. The company has issued a handsome illustrated pamphlet as a souvenir of the event, containing the tariff and instructions regarding cablegrams, which make it valuable for reference. The employés of the company were at the same time remembered, by the distribution of half a month's pay to each as a Christmas gift.

THE COMING ELECTRIC LIGHT MEETING.

The electric lighting industry has not only grown to be of great importance in itself, but it has become so closely identified with general mechanical progress that there should be a more thorough amalgamation of the interests which have heretofore wasted much of their energy in demoralizing competition. The time has passed by when local organizations must handicap themselves by paying exorbitant tribute to home companies, but there is no reason why they should go to the other extreme and endeavor to perform a really meritorious service without proper compensation. It is for the correction of various descriptions of evils, and for the discussions of improved methods that an association of electric light representatives is of special value to its members.

There is reason to believe that the first annual meeting at Baltimore, on February 10, will be a most interesting occasion, and those companies which are not earning comfortable dividends should take pains to participate in the proceedings, where they will possibly learn something to their advantage.

MONTREAL INVESTIGATING ELECTRIC STREET LIGHTING.

A special meeting of the light committee of Montreal was recently held to consider the question of electric lighting for street purposes. The city clerk presented the following statement of the cost of such systems in other cities:

Cities.	Cost per annum for each Electric Light.	Am't paid for Electric Lamps per annum.	Comparative cost of Electric and Gas Lamps.	Are Electric Lights for streets satisfactory?
Toronto, Ont.	......	$21,045 90	3 to 1.	Most satisfactory.
Ottawa, Ont.	$ 75 67	14,000 00	As shown.	Perfectly so.
New York	255 50	180,894 00	60 to 19.	Difference of opin'n
Buffalo, N. Y.	......	80,000 00	20 % more than gas.	They are, but might be improved.
Utica, N. Y.	......	12,519 00	5 to 2.	Would be if price was reduced.
Boston, Mass.	237 50	94,600 00	Twice as much.	Yes.
Worcester, Mass.	237 25	17,993 00	......	Very.
Lowell Mass.	219 00	15,330 00	6 to 1.	Perfectly so.
Philadelphia.	......	54,000 00	4 to 1.	Yes.
Washington, D.C.	......	......	......	......
Baltimore, Md.	255 50	......	......	Hear no complaints.
Indianapolis, Ind.	......	......	......	......
Portland, Me.	......	25,000 00	......	......
Elgin, Ill.	300 00	7,000 00	......	Yes.

PRIMARY BATTERY FOR ELECTRIC LIGHTING.

The Chemical Electric Light and Power Co., of Boston, is in the field with the "Volta Pavia" battery and its patented solution, which is claimed to be far superior to that formed from bichromate of potash, which has long been considered the best for the production of light or power. According to the details given by the company each cell is about 10 inches square, and fitted with a tight cover. It will hold 1½ gallons of "Volta Pavia" solution, an 8 lb. rolled zinc, a large porous cup and an improved carbon electrode. Twelve of these cells will run three 8 c. p. incandescent lamps; other numbers or powers in similar proportion, for from 150 to 300 hours. After six hours work on a closed circuit, the measurement of a single cell was as follows: Electromotive force 1.6 volts; current 5½ ampères; internal resistance $\frac{1}{100}$ ohms. The company supplies four different grades of its solution for various classes of electric work.

ORGANIZATION OF THE AMERICAN ILLUMINATING CO.

Samuel H. Willard, L. M. Bates, Henry C. Adams, A. B. Chandler, John J. Kiernan, F. K. Horn and Edward H. Goff, have filed with the secretary of state of New York, ten certificates of organization of the American Illuminating Co. The places business is to be carried on in and amounts of capital of each local organization are:—New York city, capital $300,000; Brooklyn and Harlem each $100,000, Newburg, Cohoes, Syracuse, Yonkers, Watertown, Long Island City and Ogdensburg each $30,000. The object is the manufacture, generation, utilization and sale of electricity and the furnishing of it for light, heat, power or other purposes.

ELECTRIC LIGHT AND POWER.

The city trustees of Sacramento have voted to award a contract for 33 street lamps to the Pacific Thomson-Houston company.

There are now used in Brooklyn, 372 arc lamps for street lighting, 188 in the eastern and 184 in the western district. The cost of each to the city is $182.50 per annum.

Among the electric light and power companies recently incorporated are the following, gleaned from the department of new enterprises which has been added to the other excellent features of the Boston *Journal of Commerce:*

The Edwardsville (Ill.) Light, Heat and Power Co., capital stock, $200,000; incorporators William P. Bradshaw and others. The City Incandescent Light Co., Knoxville, Tenn., capital stock, $20,000; R. N. Hood, president. The Coatesville (Pa.) Electric Light Co., capital stock, $10,000; Chas. L. Huston, treasurer. The Roberts Battery, Light and Power Co. of New York city, capital stock, $500,000; incorporators, Jas. M. Wiswell, 16 Broad street, and others. The Ouray (Cal.) Electric Light and Power Co., capital stock, $10,000; incorporators, Orland Metcalf, Irving Howbert, W. P. Peach, J. J. Hagerman and H. T. Rogers. The Colorado Springs (Col.) Electric and Illuminating Co., capital stock, $50,000; incorporators, Orland Metcalf and others. The Thomson-Houston Illuminating Co., Milwaukee, Wis., capital stock, $100,000; H. M. Benjamin, H. Nunnemacher and Louis W. Falk, 435 East Water street, incorporators. The Brush-Swan Electric Light Co., Auburn, N. Y. (formerly doing business under the same title), has been incorporated, capital stock, $100,000; Jos. A. Cook, W. F. Swift, J. Potter Byron, C. Smith and Jos. Wills, incorporators. The Merchants' Electric Light and Power Co., of New York city, capital stock, $200,000; Francis H. Wall, Ford L. Kellogg, Thomas H. Bailey, incorporators; attorney, L. Laflin Kellogg, 120 Broadway. The Plymouth Electric Light Co., Plymouth, Mass., capital stock, $25,000; incorporators, George F. Weston, Samuel Harlow, and James M. Atwood, of Plymouth, Mass., Charles E. Godfrey and G. N. Lathrop, of Somerville, Mass., James E. White and Isaac B. White, 148 W. Newton street, Boston. The Hyde Park Electric Co., Chicago (Ill.), capital stock, $100,000; incorporators, Oswell A. Bogue, 161 Lasalle street, and others. The Bristol (Conn.) Electric Light Co., capital stock, $6,000; incorporators, J. N. Sessions, and others. The Vitrite and Luminoid Co., Newark, N. J., capital stock, $400,000; Ferdinand W. Roebling, Trenton, N. J., Jonas H. Lane, New York, Walter N. Dole, 30 High street, Boston, Mass., C. M. Ball, Troy, N. Y., and Romaine Mace, Montclair, N. J., incorporators; attorney, Eugene Smith, 33 Pine street, New York.

The large cluster lamps erected by the Providence (R. I.) Gas Co. in 1883, to demonstrate the superiority of gas over electricity for street lighting have all been replaced by arc lamps, which are furnished at 33 cents per night each.

The Muscogee Cotton Mill, Columbus, Ga., is putting in gas pipes to be used whenever the electric light machinery gets out of order.

Efforts are being made to secure the trial of the Bidwell electric railway appliances at Indianapolis, Ind.

The Brush, United States, Thomson-Houston, Western Electric and Van Depoele light companies are all competing for the business at Clinton and Lyons, Ia.

Utica, N. Y., is reported as having given up electric street lighting and returned to gas, while many other towns and cities have receded from gas to kerosene.

The Western Electric Co., of Chicago, are erecting electric light plants in the following cities: Sandusky, O.; Green Bay, Wis.; Gallion, O.; Champaign, Ill., and Bucyrus, O.

The electric lighting of a rolling mill in Pittsburg, cost $2,600 during the past year. Burners adapted to the use of natural gas have been put in, and now the cost of lighting will be next to nothing.

Denver is experimenting with an electric railway. Track has been laid about three miles, up Fifteenth street and out on Capitol Hill. Professor Short, of the Denver University, is the inventor and superintendent.

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The electric headlights that have been used on some of the fast passenger engines of the Peoria & St. Louis and Columbus & Indianapolis have been removed. They dimmed the signal lights by their brightness, and had a blinding effect looking forward from the cab. Their high cost was also no small item in their use.

The Worcester Electric Light Co., Worcester, Mass., has ordered a 60 h. p. Armington & Sims' engine of the Jarvis Engineering Co. of Boston. This is the fifth engine of the kind it has purchased. This company is paying regular dividends and orders the new engine owing to the increased demand for lights.

MANUFACTURING AND TRADE NOTES.

The Holmes, Booth and Haydens Co. are erecting at Waterbury, Conn., an additional building 150 x 48, four stories high, at an estimated cost of $30,000.

Fairbanks & Co., of St. Louis, Mo., closed a contract with the Moberly Electric Light Co. for two 45 h. p. Westinghouse automatic engines, two steel boilers, a 100 h. p. National heater and a $4\frac{1}{2}$ x $2\frac{3}{4}$ x 4 duplex steam pump.

The electric light station, Haverhill, has put in two 6 foot tubular boilers set with the Jarvis furnace and the National rocking grates to burn screenings.

The Thomson-Houston Electric Light Co., Newburg, has ordered a tubular boiler and set it with the Jarvis patent furnace to burn screenings for fuel. It will use the Armington & Sims' engine.

The "Electric" leather belting furnished by Charles A. Schieren & Co., of New York, was awarded the bronze medal of "superiority" at the last (54th) annual exhibition of the American Institute.

At the meeting of the stockholders of the Westinghouse Machine Co. at Pittsburg on January 7th, the resolution assessing the stock fifty per cent., to meet the current indebtedness, was formally adopted. Stockholders have the alternative of surrendering fifty per cent. of their shares to the company. The works are shut down to take stock. By an arrangement with other stockholders, Mr. George Westinghouse, Jr., has bought fifty per cent. of the stock, and thus secures control.

The Brush Electric Company, of Cleveland, reports the trade for 1885 as excellent; works constantly employed at the same prices as for the previous year. The outlook for 1886 is good. Numerous additions and improvements to the establishment have been made, and more are contemplated.

The Ferracute Machine Co., of Bridgeton, N. J., are putting in a new 60 h. p. steel boiler, which will give them the power needed for considerably enlarging their factory, which they intend to do soon. Amongst the new tools to be put in will be a special boring mill, and several other special machines. The new Ferracute punching presses are meeting with considerable favor on account of their superior design and their great weight and strength. Amongst the orders which they have lately received for their presses is one from Germany.

MISCELLANEOUS.

The Brooklyn (N. Y.) Electric Time Co. has been incorporated with a capital stock of $50,000.

The Walter Electric Co., of Cincinnati, O., has been incorporated with a capital stock of $10,000. Incorporators, Richard R. Pullan and others.

The Telemeter Company of New York city has been incorporated. Capital stock $500,000. Erastus Wiman, 314 Broadway, and others, incorporators.

PERSONAL MENTION.

Frank L. Pope and wife sailed for Liverpool on the steamer *Gallia* January 9th, arriving at Queenstown January 18th, at 9 A. M.

The Brown Electric Co., of Chicago, has engaged Charles F. Wright, formerly manager of the Brush Electric Company's works, as superintendent.

Theodore N. Vail, president of the Metropolitan Telephone and Telegraph Co., and Joseph P. Davis, who has lately retired from the vice-presidency of the same corporation, will sail for Europe on the 2d of February for a few weeks' recreation.

Wells W. Leggett, president of the Brush Electric Light Co., recently delivered a lecture before the association of stationary engineers of Detroit.

Mr. Theodore Mace has retired from the managership of the New York branch of the Electrical Supply Co., which has grown to its present importance under his able direction. He is succeeded by Mr. H. P. Hungerford who will continue in the same line of business. Mr. Mace will hereafter represent the Vitrite and Luminoid Co., now at 14 Dey street, in the manufacture and sale of incandescent lamps.

On the 1st of February Major G. McFall of the Brush Electric Illuminating Co. will become Secretary of the Brush-Swan Electric Light Co., on the retirement of Mr. C. P. Whitney, who has spent six years in the service of the Brush system in this city, acknowledging which the company have generously granted him a four months' vacation, to the end of the business year, June 1st, without change of address. Mr. Whitney continues the agency of the Detroit Iron Tower Co. in this territory, and also the same and that of the Brush electric light system in Spanish America, where he is largely engaged in other interests.

THE TELEGRAPH.

The Air Acoustic Telegraph Co., of New York city, has been incorporated with a capital stock of $650,000.

On the 28th of December, Judge Lubke, St. Louis, granted an injunction in favor of the Western Union Telegraph Co., restraining the Guernsey & Scudder Electric Light Co. from the use of its wires nearer than three feet from the wires of the former company.

The Standard Telegraph and Conduit Co., of New York, has been organized with a capital stock of $2,500,000. The lines are to run through New York, Pennsylvania and New Jersey.

The Atlantic Telegraph Co., of Boston, has been incorporated; capital stock $5,000, for constructing underground or aerial wires in any part of the country. Parker C. Chandler, president; Charles G. Winter, treasurer.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICIAN AND ELECTRICAL ENGINEER *by* Pope & Edgecomb, *Solicitors of Patents for Electrical Inventions*, 11 *Wall Street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From December 22, 1885 to January 19, 1886 (inclusive).

Alarms and Signals:—*Annunciator*, D. S. Foote, 333,063, Dec. 22. *Fire Alarm Signal*, W. J. Keenan and E. M. Wilson, 333,131, Dec. 29. *Bell*, C. F. De Redon, 333,614, Jan. 5. *Municipal Alarm Service*, W. A. Stern, 333,975. *Alarm Apparatus*, C. H. Hilton, 334,380, Jan. 12. *Fire Alarm Indicator*, W. O. Walter, 334,399.

Clocks:—*Synchronizer Device for Pendulums*, H. Bailey, 332,987, Dec. 22. *Device for Setting Clocks*, J. F. and S. J. Kettell, 333,132, 333,133, Dec. 29. *Clock Movement*, S. C. Dickinson, 334,517, Jan. 19.

Conductors, Insulators, Supports and Systems:—*Conduit for Wires*, R. R. Taylor, 332,761, Dec. 22. *Conductor*, E. Clark, 333,110, 333,111, Dec. 29; E. Clark and T. A. Richards, 333,394. *System of Lighting*, W. Stanley, Jr., 333,564, Jan. 5. *Manufacture of Conductors*, H. R. Mason, 334,450, Jan. 19. *Underground Cable*, J. Kruesi and J. Langton, Jr., 334,708, 334,709.

Dynamo Machines and Motors:—*Dynamo*, W. Thomson, 333,174, Dec. 29; E. Thomson, 333,573, Jan. 5; Rene Thury, 333,902. *Armature for*, W. Stanley, Jr., and O. B. Shallenberger, 333,563. *Regulator for*, R. H. Mather, 334,712, Jan. 19.

Electrolysis:—*Process of Obtaining Gold, Silver, etc., from their Ores*, M. Body, 353,815, Jan. 5.

Galvanic Battery:—D. G. Fitzgerald and T. J. Jones, 333,292, Dec. 29. *Earthenware Cells for*, F. W. Meeker, 334,027, Jan. 12.

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Conducted by F. L. POPE. R. W. POPE, W. P. PHILLIPS, } Associate Editors.

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THE ELECTRIC LIGHT MEETING.

THE National Electric Light Association, although in existence but a single year has thoroughly demonstrated its usefulness. It has already attained such a position that its good influence is manifest, and it promises to assure the future prosperity of this young industry, by stamping out that feeling of bitter rivalry which frequently leads to ruinous competition and consequent distress.

Exerting nothing but a moral influence, and that natural promotion of good fellowship arising from mutual intercourse at its semi-annual gatherings, those who have participated in its deliberations cannot fail to appreciate the results already attained.

The electric lighting industry is still in its early stages of development. Economies practiced in one station are yet unknown in others. The field of usefulness in other directions is just beginning to attract the attention of capitalists. Many who visited the electric railway at Baltimore for the first time, which under most unfavorable circumstances has been in operation for six months, see possibilities in the transmission of power which they had scarcely dreamed of.

The scope of the discussion which may legitimately arise in an assemblage of this character, makes its meetings of unusual interest. The mechanic, the manufacturer, the politician, the scientist, as well as the electrical engineer, may here acquire information not readily accessible through any other channel.

Although no testimony was elicited regarding the general prosperity of the business, there was a prevailing impression that earnings were satisfactory excepting in cases where attempts had been made to successfully introduce incandescent lamps upon arc lighting circuits. An expenditure of $14 for broken lamps, against a revenue of $6 was an instance of this character. This experience was combined with a profound knowledge of steam engine economy, which however did not apply to the refinements of incandescent lighting.

The relations of electric lighting to insurance brought out some new facts regarding the rates charged for risks on stations. While it was apparent that in many cases high rates were charged by reason of inexperience, it was acknowledged that the locations of certain plants were such that they must naturally be considered hazardous. A suggestion was made that a mutual insurance association be formed among the different companies, but beyond endorsing the plan no official action was taken.

The fact that these stations are spread over a vast extent of territory adds to the feasibility of such an association, and if all plants were owned by one company, there could be no doubt that they would find it most economical to insure their own property. As this is not the case the forming of an association is the next resource. To secure immunity from extreme loss however, a competent inspector should be employed to see that proper precautions against fire are adopted, and that the plant to be insured is installed in the most approved manner. A competent inspector of this character might also be very useful as a collator of information, while his advice regarding the best methods of construction or maintenance, would be of value beyond the mere fact of his giving special attention to fire risks.

The adoption of a uniform system of itemizing the cost of construction and maintenance, which will gradually be perfected, will lead to a better knowledge of the proper methods of conducting the business. In fact the importance of the work for the general good, which is constantly looming up, points to the necessity of a bureau which will require constant attention, as a matter of important business.

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THE INDIANA TELEPHONE DECISION.

The recent decision of the Indiana supreme court upholding the constitutionality of the restrictive law regarding telephone rates, was undoubtedly a surprise to the managers of the companies interested. It is the more peculiar, on account of the character of the case, upon which the suit was brought. It appears that a gentleman living some distance from the exchange applied for telephonic connection. It was offered to him at the so-called legal rate of three dollars per month provided he would consent to being placed upon a circuit with other subscribers. He objected to this, preferring to accept the service at $11 per month, for which sum the company agreed to provide him with a special wire. Upon these grounds the suit was based. All who are familiar with the character of a well organized telephone service will admit that three dollars per month is not sufficient to pay the proper running expenses of such a system, and provide a reasonable profit. Possibly it might sustain an unreliable service, subject to those annoying interruptions which would make it dear at any price. This, however, is apparently unsatisfactory to the Hoosier subscriber. He desires not only to occupy a reserved seat, but a whole private box on a ticket for general admission. The telephone, says the learned judge has become a public necessity. Possibly it may be in certain locations; it certainly cannot be classed as a luxury.

It is rather a late day to endeavor to introduce the doctrine of universal equality, when even the national government, has drawn a sharp line, separating the aristocratic special postage stamp from its plebian associates and the still more democratic postal card. Through every ramification of our social and business life, and in every class of service performed by common carriers, among which the telephone companies are included by this decision, we find some distinction of this character, by which superior goods or facilities may be obtained at a higher price. Although apparently obnoxious in some cases, these rules are founded on common sense. A merchant ordering his goods by express would have just as legitimate an excuse for bringing suit, because a higher rate was charged than would have been the case if they had gone by freight over the same route. The man who pays ten cents to have his boots blacked in a hotel, does not file a protest because the same work is done on the street at a reduction of 50 per cent. It is unnecessary to cite the numerous parallel cases which will occur to the mind of any person giving the slightest attention to the subject. Confining our attention solely to the class of common carriers it will be readily perceived that it is for the welfare of all, that in certain emergencies the people should be permitted to secure special service.

It is not as yet decided what course the companies interested will pursue. They must eventually relinquish the business, or continue it at a loss in the hope that the decision will be reversed by the federal courts, as it undoubtedly will be. Although their contracts with the home company may require them to continue business in spite of adverse legislation, some plan will doubtless be discovered by which they can comply with the letter of the agreement without maintaining an extensive system throughout the state. Meanwhile the exploiters of mechanical telephones may occupy the field if the inducements offered are sufficient to warrant the establishment of exchanges. If the telephone is actually a public necessity, it is very probable that there will soon be a strong reaction in popular sentiment, when it is discovered that the service has so deteriorated as to be practically useless, or is withdrawn altogether.

IMPORTANT RESEARCHES IN SELF-INDUCTION.

We have received from the author advance proofs of the inaugural address delivered by Professor D. E. Hughes, F.R.S., on the occasion of his assuming the presidency of the Society of Telegraph Engineers and Electricians. A glance through it shows that we will be able to present to our readers, in the next number, an article that replies to several queries that arose at the last meeting of the National Electric Light Association in Baltimore. The paper treats of the influence exerted during the self-induction of electric currents, by the metal of the conductor. Some very remarkable results have been observed by the learned professor, which have more than scientific interest to recommend them. The underground commission, the telephone and telegraph, and also the electric lighting interests, will be thankful for the careful study he has given to the question of the duration of extra currents, and the methods of eliminating them to a considerable extent. These currents are sources of great danger in the construction of large dynamo machines, and it is not impossible that the methods of avoiding them in currents of low electromotive force may be applied here to the more intense currents. The sparking of the brushes is more due to these extra currents than to imperfect contacts, and it is probable that some of these evils may be avoided by taking advantage of the facts given in Professor Hughes's paper. He has found that the duration of extra currents increases rapidly with the section of the conductors, and he determines it by means of the telephone, in a modification of his well-known induction balance. He announced some time since that the rapidity of discharge has no direct relation with the conductivity of the metal; and the paper before us makes a study of the extra currents in their relations to the form, dimensions, and state of cohesion, of several substances, particularly copper, brass, steel, carbon and german silver. The apparatus he employs is simple, and should be adapted to the study of the phenomena that accompany the production of incandescent light on arc light circuits, as well as to the composition and arrangement of the brushes that are made to carry heavy currents from high tension machines. It is not improbable that the advantages which are admitted to accrue in the use of copper wire bundles as brushes for dynamo machines, are due to the fact which Professor Hughes has observed: that currents arising in a conductor pursue paths incident to the electro-magnetic reaction between adjacent portions of the metal. He demonstrates that the induction of a current upon itself may be greatly diminished by simply separating the paths of the current in one and the same conductor; that is, by employing bundles of wires, and of strips instead of rods, as conductors. In fact, he finds that the resistance of a conductor, and also the nature of the metal,

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less influences the extra current than the form given to that conductor.

Many unexpected, and some predicted, phenomena arise in the course of Professor Hughes's experiments, which he describes minutely. Our readers, we are sure, will enjoy and profit by the careful researches of this eminent scientist.

THE PAN-ELECTRIC TELEPHONE SPECULATION.

The government suit to test the validity of the original Bell telephone patent, has become so intermingled with the affairs of government officers, politicians, adventurers and the partisan press, that time and space devoted to its consideration is practically wasted.

As the facts are to be thoroughly investigated the people should exercise patience and await the decision, which will not turn upon the authority of the columns of a daily newspaper, whatever may be its political leanings.

Throwing aside the accusations regarding the fraudulent manner in which the patent is said to have been obtained; discarding the alleged prior discovery of the art of telephony, which was so strangely permitted to remain dormant for ten years; there does not appear to have been a legitimate excuse for the organization of the Pan-Electric Company, beyond its exploitation as a swindling speculation of the most flagrant type. We have frequently called attention to the questionable character of such organizations, but it is seldom that the internal ramifications of these concerns receive so thorough a ventilation and exposure. This is due to the national reputation of many of the gentlemen who were given an interest in it simply for the avowed purpose of gaining their influence in securing some kind of a national charter, which would apparently increase the intrinsic value of the stock. There were some phases of this operation, which are not above the level of the bunco steerer's profession. The private circulation among intended victims of an elaborate opinion that the Rogers telephone did not infringe the Bell patent, may well be considered as an attempt to obtain money under false pretenses. Unfortunately this plan of hoodwinking investors was in several instances successful, and it is fair to assume that this same legal opinion was the only tangible foundation to the whole scheme. It should be carefully noted also that the plan of organization was apparently based upon that of the American Bell Telephone Company, so that in the event of its becoming a successor to that much abused monopoly, the public would have been merely shifted into the hands of a group of hungry, self-styled philanthropists. There may be among this band of speculative pirates, an occasional individual who believes that he is engaged in an attempt to emancipate the people from paying enforced tribute to a worthless patent, but there are numerous indications that most of them are striving more vigorously to line their own pockets. This is a point which should be more generally understood than it appears to be. It is the real incentive to all this litigation, and there is no creditable feature connected with it.

Free trade in telephones, should it be established, will not be of the slightest benefit to the people at large. Out of the millions of inhabitants within telephonic speaking distance of the New York city hall, it is doubtful if two per cent. would pay even the Indiana legal rate of three dollars per month.

ANOTHER MONOPOLY IN PROSPECT.

Excepting for the fact that an arbitrary date was fixed by the original act for burying the electrical wires in New York city, there is no particular reason for undue haste in carrying out the work. Few of the fixtures common to the streets of our cities are really as harmless as the overhead wires. Time spent in deciding upon the best plan to be followed is by no means wasted. By adopting a merely experimental system, which has not been subjected to the ordeal of practical use, the final completion of this work would be greatly retarded. There are plenty of known difficulties to be provided against, while, doubtless, as many more which have not been anticipated will be encountered after construction has finally begun. The conditions are so different from those existing elsewhere, that with the exercise of all possible foresight perfection cannot be hoped for, but past experience should be availed of as far as possible.

It has recently been discovered that there is danger of the formation of a monopoly which will control the valuable subterranean franchises of the city. This should have been properly guarded against, but it will not prove obnoxious if the various companies are not compelled to occupy the proposed structure, and there is certainly a question as to whether existing corporations will be very anxious to place their wires in a conduit not under their own control. Perhaps a better feeling would prevail regarding joint occupation if the conduit was to be the property of the city, and placed in charge of one of its departments. This possibility has been partially recognized in the case of one company which proposes that a majority of its stock be placed in trust with a proper officer of the city, and also that a majority of its directors shall be appointed in behalf of the municipality where it is located. Without discussing the merits of this particular plan it is evident that some provision should be made to prevent such a consolidation of interests as might be decidedly unjust to the rights of competing companies, and it is essential that this should be done at the outset. Few monopolies are brought forth in the fullness of their strength and vigor. They represent the gradual accumulation of various minor rights and privileges, moulded into form by shrewd men of ability and experience with substantial financial backing. Such an aggregation of capital viewed from the standpoint of the chief owners is doubtless very pleasant to contemplate, and properly managed may not excite the animosity of the people. Monopolies are, however, usually expected to abuse their privileges. They do not hesitate to violate state laws in order to cripple their rivals. It is not difficult to imagine a case where they would be exceedingly annoying to their neighbors who were required to occupy adjoining apartments. Although difficulties of this character are neither electrical or mechanical, they are none the less important, and should be properly considered. This whole matter deserves conservative treatment. It has been allowed to drift along to its present stage by reason of the indifference of the very companies who should have united in perfecting a practical plan. Not working in harmony, however, they must eventually accept the situation as it is, not as they would like to have it.

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ARTICLES.

CYLINDER ARMATURES.

BY CARL HERING.

(Continued from page 424, vol. iv.)

The statements made in the first article, governing the winding of armatures, may be summarized as follows :

As two halves of the armature wire are in multiple arc, it is necessary that the electromotive force induced in both halves should be equal, that is, the number of lines of force cut per second, should be the same in both, from which it follows that the two halves should be symmetrically situated with respect to the magnetic field and the axis of rotation. The resistance of each half, or what is the same thing, the length of wire in each coil should be equal as nearly as possible, and therefore there should be as few crossings at the ends of the armature as possible, in order to make the "heads" small. As the full difference of potential of the machine may exist between the coils which cross each other at the ends of the armature, these crossings should be avoided as much as possible. On account of the short-circuiting of two or more of the coils by the brushes, these coils should be kept in the weakest part of the field, either on the neutral line, or entirely on one side of it ; each coil should come into the same position when short-circuited. The coils should be made of as few windings as possible, and therefore the number of commutator strips as large as possible. There is a slight advantage in favor of an odd number of coils, or commutator strips.

Among the different methods of winding are the Siemens, Froehlich, Breguet, Edison and Weston, besides others having no name, all of which are alike in the general principle explained in the first article, but differ in details of construction giving them advantages over each other in different respects. These different methods will be described separately, after the following general remarks which apply to all the figures.

In the following illustration these windings are represented diagramatically, as seen from the commutator end of the armature ; the dotted lines showing the wires at the other end.

For convenience in winding, the armature is generally divided into sections, which may be made any convenient multiple of the number of commutator strips, or even any other number, but for simplicity and convenience in describing and comparing them, we will, in this discussion, assume that there are always as many sections on the surface of the armature as there are commutator strips. In a completed armature, therefore, half the number of wires in each section will represent the number of turns in each coil, while each coil will fill half of two sections on opposite sides of the armature.

In the figures, the crossed hatched parts of sections represent the place occupied by one of the two halves of the whole armature wires which are in multiple arc, while the plain parts represent the other half, so that it can be seen at a glance what position these two halves of the armature wire occupy in the magnetic field. The very dark sections show the coils which are short-circuited by the brushes,and will show their position in the field when short-circuited, and also whether they are symmetrically situated or not.

For convenience in discussing them, the windings will be divided into two classes, first, those in which each coil occupies the whole depth of the winding, that is, that they lie next to each other, as in figures 3, 4, 5, 6, but not over each other ; secondly, those in which the coils or parts of coils lie over one another, as in figures 7, 8, 9, 10.

In these diagrams only eight coils and therefore eight commutator strips and sections of the armature have been taken, for the sake of clearness in the drawing ; but owing to such a small number of coils, certain proportions, such as the large space occupied by the short-circuited coil, the distortion of the line through the brushes, etc.,will appear exaggerated as compared with what they are in practice, where a greater number of commutator strips is usually taken.

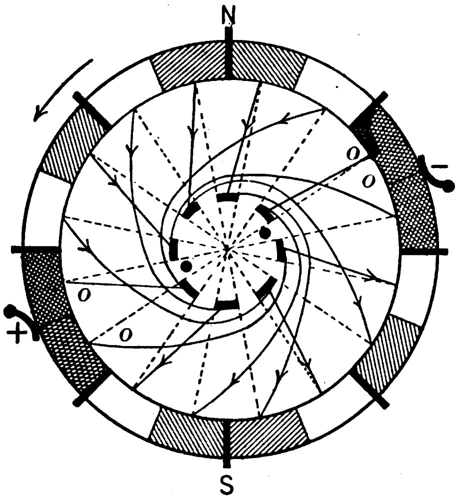

Figure 3. Siemens (old).

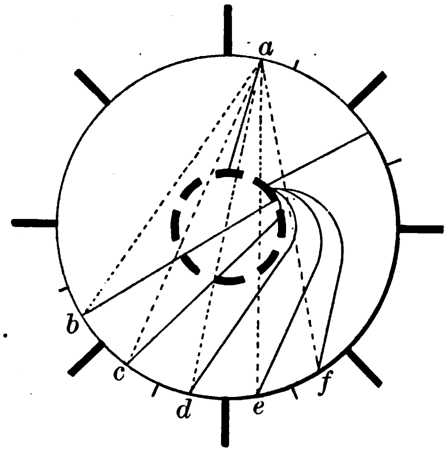

Figure 2.

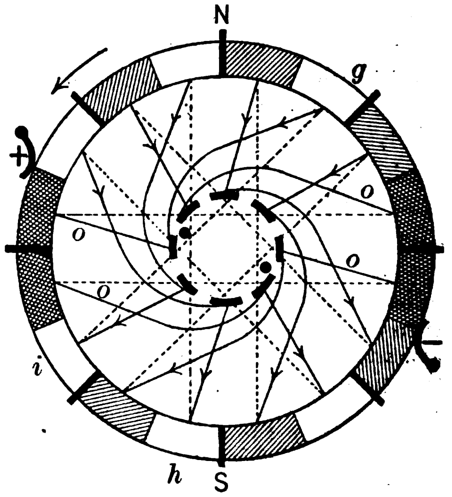

Figure 4. Froehlich.

To avoid too many lines the brushes are drawn outside of the armatures, while at the commutator their place is indicated by a small dot. The line joining the brushes can, of course, be made to take any position with respect to the poles which the designer wishes, by merely turning the commutator around on the shaft the required angle, without changing any connections. Indeed this is sometimes made use of as one of the "tricks of the trade," to make it appear as if a machine was so well designed and constructed that the neutral line is perpendicular to the line joining the poles. It is not an indication of the amount of "magnetic lag" in different machines, as is frequently supposed, unless the position of each commutator strip with respect to its coil, be the same in all the machines compared. In armatures with thick wires, the simplest and most convenient method is to fasten the beginning of each coil to the commutator strip nearest to it, as this requires the least bending of the wires. This is the method which is used in all these diagrams, the upper commutator strip being always connected with the first, upper, right-hand coil.

The direction of rotation, shown by the arrow, being assumed as contrary to that of the hands of a watch, the directions of the currents can be determined by the rule in the first article, the letters N and S representing the polarity of the pole-shoes and not that of the armature.

In figure 2, starting from the first commutator strip and winding to the first half of the upper right-hand section, *a*, we may return in one of the different parts, *b*, *c*, *d*, *e*, or *f*,

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of the sections lying opposite, or nearly so, to *a*, and then go to the next commutator strip. If we return in the diametrically opposite part, *d*, we will find it to be the Siemens winding represented in figure 3. But if we return at *e*, it gives the Froehlich winding shown in figure 4. By winding into *c*, it gives the Breguet, shown in figure 5, while winding into *f* or *b*, it will be found to make such very irregular windings, that they could not well be used, at least not in good machines, and they will therefore not be discussed here.

In winding any of the different forms, as for instance that in figure 3, it will be noticed that one whole coil must

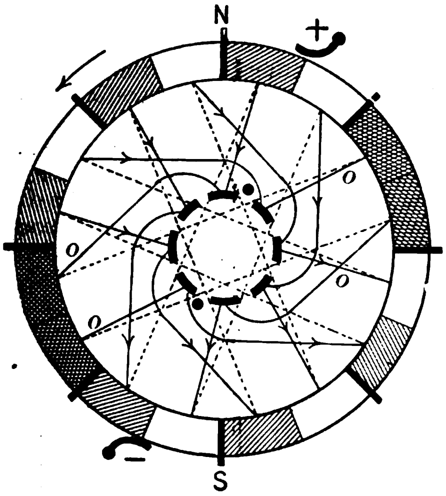

FIGURE 5. BREGUET.

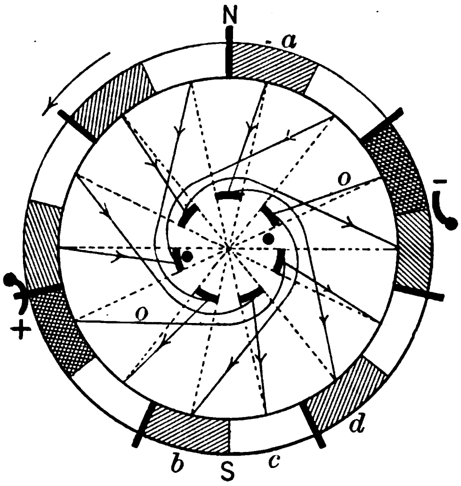

FIGURE 6. EDISON.

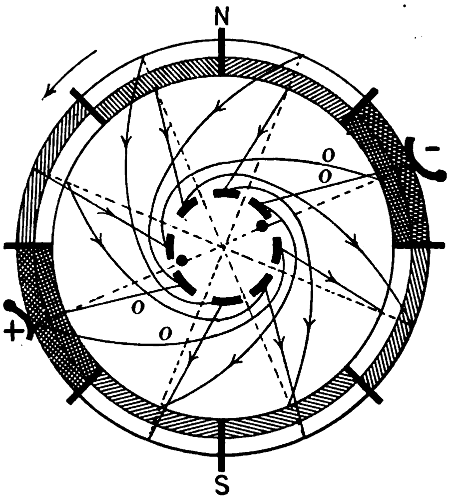

FIGURE 7. SIEMENS.

fill only half of a section on each side of the armature, otherwise there will not be room for all the coils. If the number of sections be made double the number of coils, then each coil may fill a whole section on each side of the armature. This is frequently done in practice to facilitate the winding. It will further be noticed that after having wound the first coil and connected its end to the second commutator strip, the second coil dare not be begun in the space next to the first, but must be wound in the next but one, for the next space is for the coil which belongs to the commutator strip lying diametrically opposite, and will be

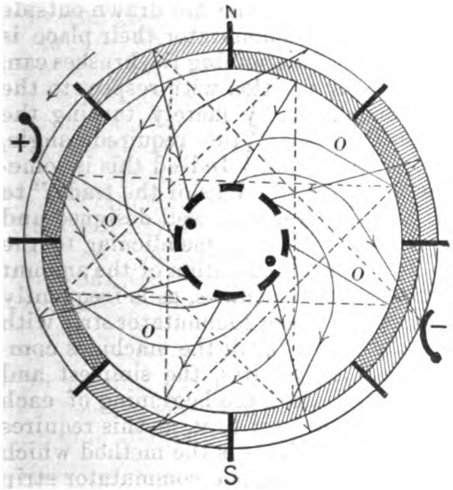

FIGURE 8. FROEHLICH.

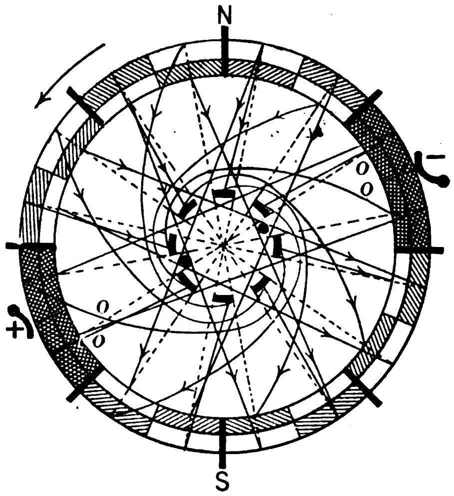

FIGURE 9. WESTON.

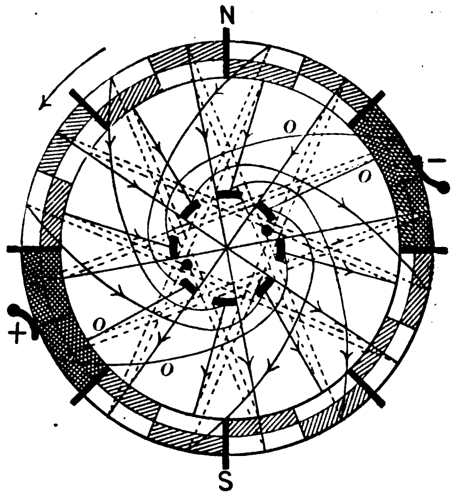

FIGURE 10. HERING.

filled by that coil after the armature is half wound. In practice they are wound in a different order than the order in which they are connected, owing to certain facilities in winding.

The Siemens winding, figure 3, commonly known as the Hefner-Alteneck, or "old Siemens," is the original or oldest form of cylinder armature invented by Hefner von Alteneck many years ago. It is now no longer used, owing probably to an irregularity in one part of the winding. Beginning with the upper commutator strip and the upper right-hand section and winding as shown by the lines, filling only half the section, then going to the second strip and to the first half of the second section, and continuing in this way, it will be found that the regular place for the fifth coil is already occupied by the first, so that the fifth coil has to be wound in the vacant half-section next to its proper place. The same is the case with all the following coils, causing a break in the regularity of the winding between the coils four and five, and a similar one between coils eight and one. From the crossed hatched and plain coils it will be seen that the two halves of the armature in multiple arc, do not occupy symmetrical positions, the crossed hatched coils having a position in a more intense field; this irregularity will cause an unequal electromotive force to be induced in the two halves of the armature windings, and is no doubt the reason of this method being abandoned. If the first and last coils be made one and the corresponding changes made in the spacing, it will no longer be irregular, and as is readily seen, will then be the Edison winding in figure 6, with an odd number of coils.

The short-circuited coil, although near the neutral line, is half in one field and half in the other, so that whatever weak currents are induced, they will always be in the same direction in the coil, and the total current short-circuited will be their sum, while in some of the other methods only their difference acts injuriously.

It will be noticed, in figure 3, that the coils all cross each

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other at the ends of the armature near the shaft thus making a large " head " at the ends. Were they all to cross at one point, the total thickness there would be at least eight times the depth of one coil ; in practice, however, these crossings are distributed over the end at different parts, thereby reducing the thickness or depth of the head.

The Froehlich winding, figure 4, otherwise known as the " new Siemens," is now used in Siemens machines in place of the old form. Starting as before in the upper right-hand section and returning in the section next to the one diametrically opposite, it will be found by following the lines, that the irregularity in the preceding method is avoided and that this, therefore, is quite regular. As every two coils are parallel there will be half as many crossings over each other at the ends, as in the Siemens, thus making the head smaller. If the crossings were all at one point, there would be only four times the thickness or depth of a coil, at the heads, while in the Siemens there were eight thicknesses. By proper distribution of these crossings, the head can be made still smaller. The two sets of coils in multiple arc will be seen to occupy quite symmetrical positions for a balanced field, which is a further advantage over the old Siemens. Another advantage is that each short-circuited coil lies entirely on one side of the neutral line, so that the current in the two halves of the coil on opposite sides of the armature is induced in opposite directions in the

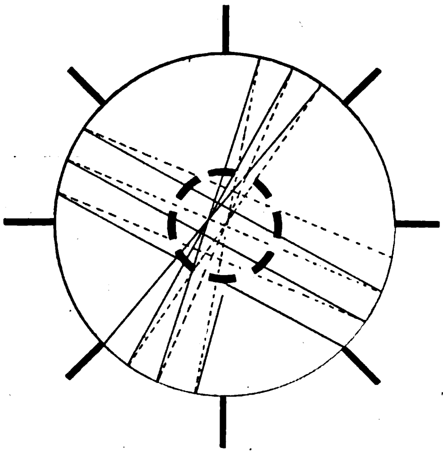

FIGURE 11.

coil itself, from which it follows that the resulting injurious current, during short-circuiting, is only their difference, while in the old form it was their sum. A disadvantage which it has over the old form is that greater care must be taken in winding it, as it is much easier to make a mistake here, the two parts of a coil not being in diametrically opposite parts of the armature; for instance, the first white coil must not be wrapped from *g* to *h*, instead of from *g* to *i*, although it may, at first sight, appear immaterial.

The Breguet winding, figure 5, is in all respects similar to the Froehlich, and all that was said about the latter applies to this one as well. Electrically it is, in fact, identical with the Froehlich, for the difference between them lies only in the position of the dividing ridges between the sections around the circumference. If all these dividing lines between the sections, shown by heavy lines, be left out on both, they will be identical mechanically. It may not appear so at first sight from the diagrams, but that is due to the difference in the connections with the commutator, which was done to avoid too many lines, but which makes no difference in the windings.

If the number of strips or coils be made an odd number, as in the old form of Edison, figure 6, the wrapping will be similar to both the old Siemens and the Froehlich. It resembles the former in the fact that the two halves of each coil are situated diametrically opposite on the surface of the armature, so that the head will be as large as in the Siemens, and what was said about the short-circuited coils, applies to it as well. But in regularity it resembles the Froehlich, while it has the further advantage over all the others, that, for a certain case of unbalanced field, the two halves in multiple arc are both affected equally. It has the further advantage over all windings with an even number of coils, that only one coil is short-circuited instead of two.

There is another form of winding, for an odd number of coils, by beginning from *a*, figure 6, and going to *c*, but it is even more irregular than the old Siemens and therefore is omitted here. By winding from *a* to *d* it will be very similar to the Edison, having the characteristics more of the Froehlich than the Siemens.

If instead of winding the coils next to each other in each section, they are wound over each other, the so-called double windings are obtained, shown in figures 7, 10. They have some advantages over the others as they are sometimes easier to wind, but some of them have the disadvantage of the coils having different lengths, not only because one is above the other, but because the upper one is wrapped over the head produced by all the lower ones, thus making it still longer. In some of the forms, the different coils have different mean radii, and therefore different linear velocities, which is a disadvantage.

Figure 7, represents the Siemens system wound double, the successive coils being alternately inside and outside. When the number of turns per coil is small and the number of commutator strips large, the double method is better than the single, for it is easier to wind. For instance, if there are only two turns per coil and two layers, it would be more difficult to wrap the two turns over each other, as in figure 3, than next to each other, as in figure 7. As the two short-circuited coils are of different radii, as seen from the figure, it follows that there will be more large coils in one half of the armature wires than in the other, thus making them have unequal lengths and therefore unequal resistances, which is a disadvantage. The double Siemens is irregular and in most other respects similar to the plain Siemens.

Figure 8, represents the Froehlich system wound double. It bears the same relation to the single, as in the case of the Siemens. The two short-circuited coils are always either both inside or both outside, while the active coils are evenly divided among the large and small ones. It has the same advantages over the double Siemens as the ordinary Froehlich has over the ordinary Siemens.

In order to get over some of the disadvantages of the double Siemens, Weston has designed an ingenious form of winding, shown in figure 9. It is the same as figure 7, except that each coil is divided into two halves, one half being inside, and the other outside, making each complete coil about the same length and making them all have the same mean radius and linear velocity. Some of the irregularities of the Siemens are thereby eliminated. It is not quite as regular as the Froehlich, as it still contains the characteristic irregularity of the old Siemens, but this disadvantage is probably reduced to a minimum. As the coils are wound to diametrically opposite spaces, the current in the short-circuited coil will be the sum of the two currents induced in the two parts of the coil lying on opposite sides, as they are on two different sides of the neutral line, the same as in the Siemens. The large number of crossings at the head is also the same in this as in the Siemens. It is somewhat more difficult to wind, but in most cases it is no doubt worth the extra trouble.

Figure 10, is another form, designed by the writer, in which each coil is split up into two parts as in the Weston, only that instead of taking the old Siemens as a basis (as in the Weston) the writer takes the Froehlich system, thus combining the advantages of the latter with those gained by dividing the coils into two parts. All that was said about the Froehlich system (figures 4 and 8) applies to this as well, besides what was said about the advantages of the Weston over the double Siemens. It will be noticed that each coil, while short-circuited, lies on one side of the neu-

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tral line, and that therefore only the difference between the induced currents in it acts detrimentally. It also has the same advantage over the Weston, which the Froehlich has over the old Siemens, that there are only half as many crossings over each other at the ends, thus making the heads smaller. As the half-coils are not wound on diametrically opposite parts, a little more care has to be taken in winding it.

The Edison system, figure 6, may also be made double, but it then appears to lose its characteristic regularity.

There are a few other systems of winding cylindrical armatures, such as that used by the Western Electric Co., and several other forms devised by Weston.[1] The former is claimed to be an improvement over the forms ordinarily used, but at the same time it is more limited in its application; the latter, we believe, are seldom used in the machines now built by that company.

Of the forms shown in the illustration we believe none but figures 6, 9, 10, are patented in this country, and may therefore be used by any one.

There remain yet a few practical points to which attention may be called, regarding all the systems. Referring to figure 2, it is immaterial whether we go from the points *b*, *c*, *d*, *e*, *f*, to the commutator strip on the left-hand of the first, instead of to the right-hand one, provided the same direction be adhered to throughout; it merely changes the position of the line of the brushes (compare figure 5 with 4) and reverses the polarity of the brushes, as will be seen by following the current around the armature. In figure 11, two coils are shown, one in which all the wires of one coil cross at the head, and the other in which they are parallel to each other. The former had better not be used as it makes the head very large.

To facilitate the winding, each section may have a dividing ridge or projection in the middle, so that each coil can be wound independently of its neighboring one; but when there are many sections, these projections occupy too much space; in the latter case, wooden blanks with a cross-section equal to the space occupied by a coil, can be fastened in each section while the first coil in that section is being wound. This keeps the wires of the first coil in each section in place, until the neighboring coil is wound.

In following the wires from the two brushes, it will be seen that they lead to two neighboring coils, showing that the whole difference of potential of the machine exists between two wires lying next to each other at the short-circuited coils. If they are not well insulated there, a jar of the machine may bruise the cotton insulation and thereby cause the armature to burn out, The danger is greatest at the heads or ends of the armature where the coils cross each other, making it very necessary to insulate the coils from each other and from the core, carefully with shellaced muslin, cardboard, pitched tape, or something similar. It has been the experience of those who have had to repair armatures, that if a coil does burn out it is generally the first or inside coil, thus necessitating the unwinding of the whole armature. This may be explained without attributing human qualities to inanimate objects, by the fact that the first or inside coil has the pressure of all the others upon it at the head, and would therefore be most likely to suffer from rough handling of a machine or armature. The Gramme ring armature has the advantage over the cylindrical, in this respect, as any coil can be unwound in the former without interfering with the rest.

In conclusion it might be well to add that some of the faults or irregularities of the different systems of winding mentioned in this article, may in practice, be reduced, by proper proportioning of the parts, to such an extent that they are no longer grave faults, thus making the different systems more nearly alike in value. On the other hand it must not be forgotten, that an irregularity may cause only a slight excess of difference of potential, but if this acts through a small resistance the current may be very great. As is well known one-tenth of a volt. is sufficient to produce 100 ampères, if the resistance is $\frac{1}{1000}$ ohms., and of some wire used in armatures for incandescent lighting it takes as much as six or seven feet to produce this small resistance.

1. See Weston's U. S. Patents.

THE MEASUREMENT OF RE-DRESSED OR ADJUSTED CURRENTS.[1]

BY E. HOSPITALIER.

It is not always sufficient to possess industrial apparatus of measurement, perfectly standardised, voltmeters and ampèremeters, and to adapt them suitably to a circuit in order to deduce from their indications the true value of the electric energy expended in the circuit.

We commit gross errors if we do not take account of the *form* of the current and of the *nature* of each measuring instrument.

This is what we purpose demonstrating theoretically and practically, making known the first results of our experiments on this important question. We have been led to this study in consequence of an observation made in March last, at the exhibition of electricity, on one of the lamps of M. Anatole Gérard, whose machine with four poles and adjusted currents is well known to our readers.

An incandescent lamp supplied by M. Gérard's machine, would seem to require a much less consumption of electrical energy than if it was supplied with strictly continuous currents, such as those furnished by accumulators, the current and the difference of potential being measured in each case with the same apparatus, that is, with an ampèremeter and a Deprez-Carpentier voltmeter.

We have been able to determine experimentally these differences with the assistance of the pupils of the School of Industrial Physics and Chemistry of the city of Paris, thanks to the courtesy of M. A. Gérard who has placed at our disposal, in his work rooms, one of his machines, and a Gramme machine giving currents so slightly undulatory that they might be regarded as continuous.

The comparisons were made by bringing the lamps to the same luminous intensity and measuring:

1. The current with a Siemens electro-dynamometer and a Deprez-Carpentier ampèremeter.

2. The difference of potential at the terminals of the lamps with a Thomson voltmeter, a Deprez-Carpentier voltmeter and a Deprez-d'Arsonval galvanometer, previously standardised.

Our experiments brought into prominence the following facts:—

1. Whatever may be the form of the current, the electro-dynamometer furnishes always the same indications for the same luminous intensity.

2. The ampèremeter yields an indication lower by 10 per cent. with adjusted currents than with continuous currents.

3. The voltmeters according to their nature, and for reasons which we shall explain immediately, furnish indications lower by 13 to 17 per cent. with adjusted currents than with continuous currents, say on the average 15 per cent.

We are thus led, if we consider the indications of these apparatus, the electro-dynamometer excepted, as exact, to ascribe to the lamps an outlay of 23.5 per cent. less in watts with Gérard's machine.

In reality it is nothing of the kind, and the cause of these apparent anomalies lies in the form of the current and in the nature of the apparatus employed for measurement.

If we refer to Joule's formula:—

$$W = R\,I^2\,t$$

we see that the energy, W, expended in an electric circuit during a given time, t, is proportional to its resistance R, and to the square of the intensity, I. If the current is variable during the time, t, as in Gérard's machine, the energy expended during the time, t, is proportional to the

1. *L'Electricien.*

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mean of the squares of the intensity and is consequently proportional to the indications of the electro-dynamometer, which gives precisely the mean of the squares. An ampèremeter like that of Deprez-Carpentier gives only the mean intensity, and it is easy to see that except in the case of an absolutely continuous current the square of the mean intensity is always smaller than the mean of the squares of the intensity.

It is only in the case of I being constant that

$$\left(\frac{1}{T}\int_0^T I\,d\,t\right)^2$$

representing the square of mean intensity and

$$\frac{1}{T^2}\int_0^T I^2\,d\,t$$

representing the mean of the squares of intensity have the same value.

With a current of a perfect sinoidal form calculation shows that the difference of the intensities reaches 10 per cent., the exact figure found by experiment.

If we take Joule's formula in the form

$$W = \frac{E^2}{R}\,t$$

reasoning analogous to the above shows that the indication of a Deprez-Carpentier voltmeter cannot when raised to the square, give more than the square of this difference of mean potential, always less than the mean of the squares of the difference of potential.

Theory in the case of a perfectly sinoidal current indicates a difference of 10 per cent.

In fact, the difference is greater because the self-induction proper to the voltmeter produces in the case of variable currents a counter-electromotive force which diminishes the intensity in the circuit of the voltmeter and further lessens the indications. This cause of error naturally varies with the coefficient of self-induction in the measuring apparatus. This explains the differences of the indications of the different voltmeters employed when making use of fluctuating currents, whilst these differences are nil with continuous currents.

CONCLUSIONS.

Ampèremeters and voltmeters, which by their principle of construction furnish indications respectively proportional to the mean of the intensities and to the mean of the differences of potential, are not fit for measuring adjusted or very undulatory currents, and furnish too low values for the product $E\,I$.

With currents of this kind it is necessary to employ apparatus whose indications are proportional to the mean of the squares. Moreover, as far as voltmeters are concerned, the coefficient of self-induction must be nil, or so small that it may be neglected.

The electro-dynamometer of Siemens is fit for measuring currents, and the quadrant electrometer (idiostatic method) and Cardew's voltmeter may serve for measuring the differences of potential. The product of their indications gives the true value in watts of the mean electric power, whatever may be the form of the current. Their use does not admit of the reservations which we have just made concerning the magnetic apparatus, which hitherto have been almost exclusively used industrially.

It is then indispensable before procuring a measuring apparatus, to know very exactly all the peculiarities of the currents for which it is destined, for fear of committing serious errors and losing all the benefit of its use.

CORRECTION OF AN ERROR IN ELECTRO-DYNAMICS.

BY PROF. W. L. HOOPER.

It is not infrequently supposed that there is an expenditure of energy in the coils of an electro-magnet sustaining a load or in a coil of wire containing an iron core other than that due to the resistance *per se* of the wire.

The above is plainly stated in at least one somewhat prominent book on electricity with which I am familiar, and given as an illustration of the conservation of energy. Some months ago I undertook, with the assistance of one of my students, the investigation of this phenomena.

A tangent galvanometer with a coil having a diameter of about two-thirds of a meter consisting of five turns of stout wire was improvised. A piece of magnetized watch spring, 1 cm in length, attached to the back of a small mirror hung by a silk fibre in a tight box constituted the needle. Deflections were read with a lamp and scale 1 m distant. The battery, galvanometer and electro-magnet formed a simple circuit.

Owing to the facts that the needle was sometime in coming to rest and that the battery was not absolutely constant, changes in the current strength less than a considerable fraction of 1% could not certainly have been detected.

We accordingly tried another plan and made the electro-magnet one of the four resistances of what was practically a Wheatstone bridge arrangement. We were here troubled greatly by the unequal heating of the various conductors by the strong current used; nevertheless if the apparent change in resistance of the electro-magnet when lifting a load had exceeded a few hundreths of 1% we should have detected it.

The same was true of a coil of wire with an iron core; no change due to the iron core was suspected.

It was here resolved to renew the experiments on the completion of a divided meter bridge then projected. The subject was accordingly again taken up a few weeks ago.

The slide wire of the bridge is a meter in length, the prolongations used in the side gaps were a little less and a little more respectively than 41.5 m of the slide wire; hence the equivalent slide wire was about 84 m. in length. The electro-magnet was placed in one of the central gaps, in the other a nearly equal resistance carefully selected, so that the heat developed by the current should affect both alike.

The battery used consisted of six large bichromate dip cells having an electromotive force of 11.8 volts and an internal resistance of .3 ohms. After some preliminary experimenting the following order was adhered to. After closing the battery circuit the armature with a load of about 65 lbs. was placed upon the electro-magnet; the man at the Thomson reflector in an adjoining room was then directed to close the galvanometer circuit, if necessary the bridge was adjusted till the spot of light stood steadily at zero.

The galvanometer circuit was then broken and immediately afterwards the battery circuit was opened, when the armature fell off; the circuits were then quickly closed in the inverse order and the deflections observed. After several precautions, unnecessary here to relate, had been adopted, the above could be done without any perceptible motion of the spot of light.

It will be remembered that the equivalent length of the slide wire was 84,000 mm; now a motion of 1 mm of the pointer was found to give a deflection of a little over three divisions on the scale of the galvanometer.

Hence it is not too much to say that if anything much exceeding the one millionth of the energy of the current had been absorbed in doing work upon the armature of the electro-magnet, it would have been detected.

Of course in the light of the modern theory of electro-dynamics the result could not have been otherwise; still it seems to me important to correct mistakes by an appeal to experiment wherever possible.

PHYSICAL LABORATORY,
TUFTS COLLEGE, Dec. 9, 1885.

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ELECTRICITY AS AN ILLUMINANT.[1]

BY OTTO A. MOSES, PH. D.

In the following brief review your committee on "Electricity as an Illuminant" have thought it advisable to treat of the advance in electric lighting as having been marked by periods of activity. The present uniform development indicates the near approach of another period in the history of this new and great industry, when electric light will occupy the position now held by gas as an illuminant. The subject is one that engages universal public attention, owing to the extent and wide distribution of gas interests, and because of the possible effect the growth of electric lighting may have on the value of petroleum and natural gas *in situ*, as one of the future sources from which most illumination will be derived for use in the populous parts of the country.

In the conflict between electricity and gas as an illuminant, there is no point of advantage in favor of gas, except its cheapness. But this advantage will every day diminish, while the superior healthfulness of electric light, and its greater safety against fire, and the ease with which it lends itself to decoration, must force its acceptance by the public long before the equality of cost is reached.

We have divided a short history of electric light into five periods, which we will call by the following titles:

1st. The period of Davy.
2d. The period of Starr and Staite.
3d. The period of the Alliance machine.
4th. The period of the Paris Exposition.
5th. The coming period.

Each one of the first four epochs has been marked by some great and essential development in which electric lighting approached much nearer to perfection.

THE PERIOD OF DAVY.

In 1813, Sir Humphrey Davy was engaged in establishing his fame in a series of brilliant lectures at the Royal Institution. He had decomposed the alkalies and had produced sodium and potassium in their metallic state by means of the powerful current from a battery of 2,000 zinc-copper elements. With these cells he was the first to make the electric light.

In his classical experiments he produced:

1. The arc light in air, and in the vacuum of an air pump.
2. The incandescent light in air, and in the vacuum of an air pump.
3. For these purposes he made use of small pencils and rods of carbon from vegetable fibre, and in the dense form of the diamond.
4. He discovered that a point of rarefaction in different gases could be reached where the arc would not pass.

Schemes of electric lighting as early as this may naturally have floated in the heads of visionary inventors; but, if they ever experimented in this direction, the rapid polarization of Sir Humphrey's primitive batteries and the difficulty of keeping an air pump tight, would soon have dispelled their hopes. Gas too, had just been introduced into London with great eclat; for we read of the vast illuminations made with it in honor of the crowned heads who visited that city after the fall of Napoleon I.; and so the electric light was laid aside.

From 1813, when Davy experimented with the electric light, until 1841, when Archereau and Deleuil used it to illuminate the Place de la Concorde in Paris, nothing seems to have been done to develop the necessary machinery for its automatic working, those gentlemen being compelled to push the carbons by hand as they were consumed.

In the meantime Grove (1832) had invented his depolarizing battery, and Bunsen had modified it by substituting carbon for platinum, and incidentally the latter had learned to make artificial carbon better adapted than wood charcoal for arc lights.

So bright a light as that produced by Deleuil with 100 Bunsen cells, and one so well adapted for fine effects could not fail to attract inventors. In the same year another departure in electric lighting—incandescence of platinum and charcoal, or plumbago in vacuo—was made by an Englishman named F. de Moleyns.

THE PERIOD OF STARR AND STAITE.

It was not, however, until 1845 that any serious attempt was made to introduce small electric lamps into public use, when J. W. Starr, a native of Cincinnati, went to England with an incandescent electric lamp having a carbon made to give light while in a Torricellian vacuum and over mercury. Here, with the assistance of Mr. George Peabody the banker, he introduced it, but soon after died.

The next year a very ingenious Englishman named Staite took up the subject of electric lighting in all departments, and in a short space of time produced excellent arc lamps embodying many principles now, or recently, in use. He also patented an incandescent lamp in which the illuminating organ made use of was iridium, as superior to platinum. He, also, much perfected the carbon used in arc lighting.

The great difficulty in his way was the want of a cheap source of electricity, batteries being found too expensive. This defect prevented his success.

Here the matter seemed to rest (if we except Archereau's application of the solenoid to arc lamps, in 1848) until the invention of the dynamo machine furnished the missing link to the chain of inventions which had to be wrought before electric light could be commercially produced.

It is perhaps well here to note that it is claimed by M. de Changy that he, and M. Jobard, of Brussels, in 1855 had made but not operated, incandescent lamps identical in form with lamps now in general use; but his claims are not substantiated.

It may also be mentioned that simultaneously with the invention of the dynamo-electric machine a patent for an incandescent lamp was taken out in England (by one Shepard) for a Belgian inventor named Nollet, presumably the same person as he who conceived the dynamo (now in operation) called after the company who manufactured it, the Alliance machine, and which remarkable machine when constructed and improved by Van Malderen, first rendered electric lighting feasible.

The perfect germs of this latter engine were, however, found buried in the small magneto-electric instruments of Pixii, Clarke, and Page, which had been constructed almost immediately after Faraday announced his grand discovery of magneto-electric induction.

It is also necessary to recall that Elias, and Stohrer, in 1844, King in 1846, Dujardin in 1847, Henly in 1849, had already done a great deal to render the dynamo possible.

THE PERIOD OF THE ALLIANCE MACHINE.

The Alliance machine was originally intended to be used as a source of light by employing, for that purpose, the gases of water decomposed by its continuous currents. This fallacy was soon abandoned and the machine converted into an alternating current one to be applied to electric lighting. It was set at work in a lighthouse at Havre, where it is to-day (as one of your committee has seen) doing very good work, never having been out of order from the day it started in 1863.

A host of able inventors then began to develop the dynamo machine. Among these we would call especial attention to one who was far in advance of his time, and the anticipator of many recent inventions: Hjorth, of Denmark, who in 1854–55 took out excellent patents in which the principle of augmenting electric currents by the reaction of electro-magnets upon each other was clearly described; as also the principle of exciting the field magnets by means of permanent ones.

Werner Siemens, of Berlin, constructed his armature in 1856.

Prof. Holmes, of England, made a machine which, when

1. Report of the committee read before the National Electric Light Association, Baltimore, February 11th, 1886.

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approved by Faraday, was used by the British government in an important lighthouse in 1856.

In 1858, an unknown inventor (represented by J. H. Johnson, of London) first suggested the auto-exciting principle, which afterwards was independently discovered and presented to the Royal Society by W. Siemens and by Wheatstone.

In 1860, a new departure was made in the history of electric lighting, by Antonio Paccinotti, of Italy, who constructed continuous current dynamo machines (which he also used as motors). In these most remarkable machines all the principles now employed are found. But it is worthy of notice, although attention has never yet been called to the fact, that the auto-exciting capacity of the field magnets (above referred to) escaped the inventor's observation; and also the action and reaction principle first observed (we believe) by Fontaine on accidentally coupling two Gramme machines together.

Wilde (1863), Varley (1866), Wheatstone and Siemens (1867), constructed machines containing the principles of the inventions just referred to, but which were independently discovered by them.

Prof. Rowland, of Baltimore, also, about this time (in 1868) had devised apparatus containing leading principles.

As your committee only propose to indicate the chief periods of development in the dynamo in its relation to electric light, we must here call especial attention to the machine invented by Z. T. Gramme, of Paris, in 1869.

Although this machine was entirely an original invention, it varied little from that first described by Paccinotti in *Il Nuovo Cimento*, in 1863; still its simplicity and efficacy caused an entire revolution in the production of electric light.

In the time which elapsed from the date of its invention to the Paris exposition (1881) electric lighting became a business ; but only by means of the arc light.

However, the possession of so convenient a source of electric power as the dynamo, gave a great stimulus to inventors, and several again took up the subject of incandescent lighting. This new enterprise began in Russia, and in the course of a short time Messrs. Lodyguine, Konn and Bouleguine, of St. Petersburg, constructed and put in operation, commercially, incandescent lamps with thin carbons, in vacua, contained in glass globes cemented in various ways.

Experiments had also been made with Geissler tubes by Messrs. Benoit, who employed them as a source of light for miners' lamps.

It is necessary here to recollect that the invention of the Geissler and the Sprengel mercury pumps ; the elaborate and classic studies of Pflucker, Crookes, Gassiot, De la Rive, and others ; and the perfection attained by Carre, Gaudoin, and others, in the manufacture of electric light carbons, had paved the way for the successful construction of incandescent and semi-incandescent lamps ; and thus enabled Werderman, Jablochkoff, Swan, Edison, and many other inventors, to engage in their manufacture and improvement ; so that at the Paris exposition in 1881, it was possible to show lamps that have not undergone much change in form since that day. So much so that capitalists became convinced that electric lighting had reached a point where they could invest in its development.

THE PARIS EXPOSITION.

This period is memorable for the wonderful impetus given to electric lighting, and for the opportunity it afforded to investigate the claims and merits of rival inventors by a comparison of the extensive collections of historic apparatus exhibited. Other expositions exclusively devoted to electric subjects were held in London, Vienna, Munich, Philadelphia and other places, and through their united influence electric lighting has impressed itself upon the business of the age.

THE COMING PERIOD.

Much has yet to be done by discovery, invention, and development before electric lighting will occupy the commanding position it will inevitably assume ; and in conclusion of this report your committee would call attention to the new fields which are to be explored, and to the directions in which what we have is to be developed and perfected.

CENTRAL STATIONS.

The distribution of electric power from central points is going to be the future source of energy, for light and other purposes, in cities. These points will be in the coal, petroleum and gas districts, and in the neighborhood of large water powers. The power which will reach the cities will be stored at central stations, or be transformed there for general distribution. Enormously expensive and cumbersome systems of distribution will be abandoned, and currents of high potential must be safely transformed into currents of low potential at the door of the consumer, or if not needed be stored for future use. At present, central stations employ their capital fruitfully only about six hours in twenty-four. This must be avoided by using the plant, when light is not wanted, in storing and distributing currents of different potentials to local transforming centres of consumption, by means of more than one system of radial conductors.

TRANSFORMATION DIRECT OF FUEL INTO ELECTRIC LIGHT.

The greatest problem that can now occupy the mind of the electrician is the generation of electricity directly by decomposition of the hydro carbons, etc., without the intervention of the dynamo. The solution of this problem will simplify the production at the coal fields, etc., and the discovery will reward the one who makes it with untold wealth and honor.

There is an immense field for activity in perfecting and applying thermo-piles, accumulators, potential transformers, Geissler tubes, incandescent lamps, arc lamps, semi-incandescent lamps, meters, gas engines, etc., to electric light purposes.

The engineer who applies himself to these subjects has a mine of wealth before him. Let him remember that electric lighting as a business did not exist 10 years ago, and let him also recollect that gas lighting is the largest manufacturing industry in the world, and that electric light will be welcomed in every place where gas has poisoned and blinded with its fume and flicker.

PROPER CONSTRUCTION AND MAINTENANCE OF ARC LIGHTING CIRCUITS.[1]

BY E. R. WEEKS.

As the subjects of underground conduit and incandescent lighting were assigned to other committees, the following notes will apply to aerial arc circuits only.

Under the head of construction, may be considered linewire, supports, lamps and station connections; under that of maintenance, lines, lamps and dynamos. Since the important subject of line wire was given to another committee, its discussion is omitted.

To guard against "trouble" and to facilitate its removal the line should, as far as possible, be in sight from the ground, and should be so placed as to be readily reached. By such construction, trouble and the cost of attendance are reduced to a minimum, and one is freed from the endless complications of housetop work, with its manifold objections, *i. e.*, rights to be begged, bought or stolen; continuous delays in removing "trouble"; costly repairs to roofs, chimneys and fire-walls; together with all the thrilling adventures of a Boston lineman.

On some narrow and overcrowded streets, it may be policy to erect iron standards; but the danger of fire and of ground shocks is so great with such supports, that those of wood are much to be preferred.

To prevent the insulations being cut by tie wires and to

1. From the committee upon this subject. Read before the National Electric Light Association, Baltimore, February 10th, 1886.

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guard against excessive slack from stretching, poles should not be more than one hundred feet apart. With the best material and good workmanship, and by paying more attention to the general appearance of the line, we may gain in efficiency and do much toward silencing the outcry against overhead wires.

Aside from the necessity to comply therewith, the rules of the Board of Underwriters should be observed, because they are founded in reason and are *generally* conducive to the interests of all parties. There *must* be a positive "cut out" on every loop. But, instead of placing it upon the building containing the lamps to be cut off, it has been found better to provide for it a special pole or support as near as possible of course, to the entrance to the building, but independent of it or of any structure which is likely to be destroyed by fire. By so doing, control of the circuit is retained in the event of the total destruction of the building containing the loop. There have been instances where such an arrangement would have saved the circuit and prevented loss from rebate. Where high tension currents are employed, porcelain should not be used for outside insulation. The best insulators for this service are of hard rubber and of glass. By means of wall-blocks and brackets, rubber hooks and glass insulators may be used for all outside work where it is common to employ porcelain knobs.

In entering buildings additional insulation of hard rubber tubing should be used. To avoid damage from water, have entrance holes bored upward from the outside, and let the wire run from a fixture placed below the exterior opening, so that all drip shall be away from the building. For like drainage purposes, glass insulators are to be set at an upward angle and rubber hooks pointed downward.

Lamps must be suspended by some perfect insulator; vulcanized rings being the best known to our experience. The best service is given by stationary lamps. This is especially true of outside lights. Those hung with raising and lowering tackle are more liable to wear, breakage and variable contacts than are rigid lamps; and in cold weather the tackle may become so clogged with ice as to render them inaccessible. For like reasons, when it is necessary to place the light toward the middle of the street, some device similar to the Brady mast-arm will prove most satisfactory.

Hoods should be sufficiently large not only to protect the lamp from the weather, but to allow access to its works while it is in service. The conical form, since it offers least resistance to the wind, is preferable to other shapes.

Globes should be deep enough to cover the arc when the lamp is trimmed full; and the aperture at the top should be no wider than will just allow the rod and holder to pass freely.

The dynamo room should be a clean, dry, well ventilated apartment. In no other can electrical machinery be kept in a condition to do the best and most reliable work. Let every dynamo be set on some sort of frame by means of which the tension of the belt can be easily changed; and in addition, let it be carefully insulated from this frame by blocks of paraffined wood or some other equally good insulation. Wires from the machine to the switch board are best run either by way of the ceiling or beneath the flooring. Under no circumstances should they be laid upon the floor, where they are not only in the way, but are sure to lose their insulation through dirt and wear.

All station wires should be cased in rubber tubing as high as a man's head, and cables and lines connected with the switch boards must have similar coverings to guard against short circuits, fire, and injury to employés. To protect both machines and lamps, and the property of patrons, every circuit ought to have lightning arresters at the station, one on each wire.

The proper maintenance of lines requires that all other wires be excluded from electric light poles. The apparent economy of partnership poles is more than offset by the increased care required to maintain lines in good condition. Such a combined system will result in greater danger of crosses and grounds, fires will be more frequent, and the lives of men unacquainted with the handling of electric light wires will be jeopardized.

The insulation of circuits should be tested several times daily, and all lines, patrolled frequently. In searching for grounds and in repairing open circuits, much time may be saved by using a magneto. Having attached the two wires of the open circuit to the station bell-box, the line man, with a duplicate magneto, goes to the break. When the wires are ready for connection, he uses the magneto to signal the station that the current may be turned on in five minutes, or some other previously determined period. In this way, a search for a telephone, or a walk to the station will be avoided, and rebates will be reduced.

Dirt must not be allowed to accumulate on any part of the lamp. Rods, bases, switches, contacts, bushings, and globes should be kept clean, and screws well set. Rods require frequent burnishing with crocus cloth. Let there be a system of rigid inspection at varying intervals, and full and exact reports from the inspector as to the work of each lamp man.

If properly tended, lamps need very little adjusting. In nine cases out of ten, adjusting simply means cleaning. But one man should attend to the adjustment of any set of lamps; and these if properly cared for by the lamp man, ought to run for a long period, with little other attention. As often as once in two years at least, it is well for the lamps to be returned to the station to receive a thorough overhauling, and to be repainted that they may present as creditable an appearance as possible.

In the annual contract, with the consumer, there should be a clause especially stating that any working with the lamp by other than electric light employés, will relieve the lighting company from all responsibility for failure of light. Employés should be provided with badges worn in plain sight.

Machines run in series do not give as good results as when run singly. The tension is increased to the danger point, while oscillation and all other kinds of trouble are more difficult to overcome.

The insulation of dynamos must be tested as often as is that of the outside circuit, and all circuit connections and binding foot screws must be kept tight.

Having given the machine the most favorable setting, it still needs intelligent attention to maintain it in an efficient condition. Except in an unusual emergency, the necessity for calling an expert, will generally mean that the machine has not had proper care. The insulating parts will probably be found greasy and gummy and coated with metallic dust, which destroys insulation and causes trouble of various kinds.

In conclusion, it may be said that if circuits are properly constructed and cared for, they should work satisfactorily. If they do not do so, if they are in constant need of repairs, if lamps require frequent adjustments, if bushings are continually burning out; the *meaning* is careless attendance; and of all this carelessness, failure in cleanliness will be found the most common fault. Given a well constructed circuit, cleanliness is the ounce of prevention that will obviate 90 per cent. of the vexations of electric lighting.

OPERATING EXPENSES OF ELECTRIC LIGHT PLANTS.[1]

BY E. R. WEEKS.

WERE it possible to make an estimate of operating expenses that would be an average for all parts of the country and for various plants, the result would be of compara-

1. Read before the National Electric Light Association, Baltimore, February 12th, 1886.

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tively little value. Conditions are so different that exactly the same plant would require a much larger expenditure in one locality than in another. Water power may be available in one city, and the operating expense of the power department be reduced to an inconsiderable amount. Again, proximity to fuel supplies will give this item a subordinate place. The wide difference in the size of plants does not make a corresponding difference in expenses, even in a given plant, an increase in the number of lamps does not equally effect the expense in all departments, nor is the change in operating expenses in direct ratio to the increase. A plant of incandescent lights does not give the same relative per cent. of expenditure for lamps and for power as obtains in an arc plant; the single item of attendance in the lamp department being much less for the former.

In making an estimate of operating expenses, therefore, it has been thought best to take as a basis an arc plant of 200 lamps, and leave as much margin as possible for the varying conditions which affect the cost of labor and supplies.

As water power is available in few cases, it has not been considered, this report being based upon the supposition that most plants must be operated by steam, which necessitates large expenditure for machinery, fuel and attendance, and renders the question of economic measures highly important, both to the furnisher of light and its consumer.

In establishing a plant, two items enter into the calculation of financial returns—the original cost of machinery, and the expense of running it.

In no other business does so close a relation exist between the quality of machinery, the operating expenses, and the net gain. In other industries it pays to buy the best implements; in electric lighting anything else is a loss. Reliability is the first consideration. It is not necessary to say to a body of electric light men that stoppage means rebate, rebate means loss, not only in immediate returns, but in confidence from customers, and so greater financial loss.

Every piece of machinery should be chosen not with reference to its price, but to the dependence that can be placed upon its steady efficient service. The best engine is not good enough! Many a lighting plant has failed because of a poor one. There should be an automatic cut-off, and all bearings should be large and strong. The governor should be perfect, so that a change in load shall not result in a change in speed, and a consequent variation in the lights. If given its maximum load, a large engine is much more economical than a number of small ones; but in case of stoppage the loss increases in proportion to the number of lights.

Economy requires a fair grade of oil freely used. Heated bearings result equally from the clogging of poor oil and the stinted use of a good one; and they necessitate stops, with a consequent loss of time and its aggravating train of results. The seeming waste from a free use of oil may be prevented by a system of drainage, which will preserve the drip to be used over again, finally to be sold.

Where the water is full of impurities, *special* attention must be given to the construction of the boiler, which should be such as to allow a free circulation, and render all parts easy of access. The *best* boilers require frequent cleanings, with thorough inspection at least once every three months. Heaters should be of such design, grates of such pattern, and all steam apparatus so set up and adjusted as to allow the use of the lowest grades of fuel in the most economic way. Fuel being a heavy item of expense, an attentive fireman, capable of intelligent judgment as to the greatest amount of heat to be obtained from a given quantity of fuel, is a profitable investment—$2.00 per day is but value received for the services of such a man. In a 200 arc plant he can save more than his salary, and, in addition, can produce from a cheap grade of coal better results than can be gained by the ignorant use of the most costly fuel.

As was plainly shown at our last convention, the cost of fuel is a widely varying item; one, indeed, upon which there seems to be no common ground except the desire to reduce it. According to the varying grades, and the different methods of handling, from three to fourteen pounds of coal per lamp per hour are required; and its price ranges from $3.50 to $0.50 per ton.

As the most efficient service demands the closest attention on the part of engineer and fireman, too long a watch should not be required.

Basing our calculations upon a good mixture of slack and nut coal for a 200 arc plant at an average distance from the fuel supply, the cost of the power department should be not far from 32 per cent. of the whole operating expense.

Even with the most carefully constructed lines, having supports not over 100 feet apart, inspection of the whole circuit should be made every two or three days; especially in cities where there are narrow streets, or a great number of wires. A good line foreman is worth from $15 to $20 per week, and he should keep his department within 7 per cent. of the total operating expenses.

Economy requires an absolutely automatic regulation of the current; and the most satisfactory service will be secured when the tension is not too high. The object sought should be, not the greatest amount of light on a given circuit—but the greatest amount consistent with a reasonable degree of safety.

Several years of experience seem to have demonstrated that a light double-leather endless belt without rivets is best, giving the greatest security against stoppage, and steadier pull for the machine than result from other kinds of belting. In the care of dynamos, cleanliness can not be too rigidly exacted. *Cleanliness* here is the watchword not only of success but of true economy. A neat, rapid and observant attendant is absolutely necessary, that trouble and expense may be avoided. To prevent costly delays, all bushings, insulations, etc., should be cleaned daily; frequent inspection of their condition should be made, and they should be found in a state that would leave the white kids of a West Point inspector free from the slightest stain.

The cost of running the dynamo department should form about 14 per cent. of the whole operating expense.

Single lamps with larger carbons, even when they must be re-trimmed during service, are more economical than the duplex lamps. The globes used on the latter are more expensive and are more frequently broken. The unequal expansion produced by heating the side adjacent to the arc, and the sudden change in temperature from the shifting of the arc to the other side, always lead to this result in double lamps. The loss on them in this direction alone would almost pay for the extra service of retrimming single lamps. Moreover, owing to the crowded condition of the box of the duplex lamp, it is more apt to get out of order, and, for the same reason, is more difficult to readjust; and, as carbons are not uniform in their lasting qualities, the loss from burnt holders reaches its maximum where this lamp is used.

Outside lights give more reliable service when rigidly hung and the same is true for inside lamps, unless a device similar to that exhibited at Chicago by the Western Electric Company be used. Light hard-wood ladders and a good lamp man, will have a better effect upon operating expenses than the ordinary loose tackle for raising and lowering. The ladder is, of course, less convenient, but a lamp properly trimmed with it, is in no danger from the frequent variable contacts caused by raising.

In the use of carbons a certain amount of waste must always result; but this item can be considerably reduced by trimming short time lamps with pieces. The carbon

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question properly belongs to another committee, but it may be said here that cheap grades are a constant source of annoyance and loss.

Globes are a vexatious part of the best lamps, and swell the item of breakage despite the utmost care. In fact there is no profit in them, except for the manufacturer. Nine-tenths of this breakage is due to the unequal expansion resulting from over-heating. The most feasible of the proposed preventive measures would be the use of a sheet of asbestos packing, which would insulate the globe from the undue heat at the lamp base.

Perfect trimming of lamps, as early as possible in the day, should be insisted upon. Switches, bases and all contacts must be well cleaned. Rods should be wiped before being pushed up, and in scouring them nothing but crocus cloth should be used. In exposed places they should also be provided with protectors. All screws and contacts must be kept tight. A careful lamp man, without patrol duty, can trim 100 lamps per day, while for one who patrols his own circuit, from 25 to 50, according to distribution and service, is a reasonable number. Such men are worth at least $1.50 per day.

With reference to the lamp department, there should be a thorough system of, at least, fortnightly inspection, with reports of trouble and breakage, and their causes.

With careful attention, the expense in the lamp department should not amount to more than 28 per cent. of the operating expenses.

As the cost of installation and attendance is generally borne by those manufacturing light, as all fixtures are usually furnished by them, and as the change in seasons produces but slight variations in operating expenses, it is only fair to ask that the revenue be equally uniform. Hence contracts should be annual; circuits should not be cut for transient business without adequate compensation. This is difficult to fix, but it should be at least one-third more per month than the yearly rate.

We do not offer this paper as a satisfactory or comprehensive report on operating expenses. Data upon which to found estimates of real value have not been accessible, owing to an evident reluctance to make them known. The subject is, however, one of the most important that can occupy our attention. Upon it chiefly depends the future spread and financial success of electric lighting. Our business is new, and its operation so different from that of other industries, that we cannot draw largely from their experience. At the same time, the public is no longer so patient of slow and awkward experiments at its expense as it was in the early days of telegraphy. People demand immediate perfection in the thing for which they pay.

It, therefore, behooves each one of our members to give freely and fully of his experience to our common fund of knowledge, that our industry may gain a sure and substantial paying basis in the shortest time possible. We would therefore suggest that a standing committee be appointed to receive statistics in regard to the various operating expenses—that this committee adopt a form of blank analysis to be furnished to each member of the association, whose personal duty it shall be to fill out such blanks monthly, and forward them to the chairman of the standing committee—that this committee compile and present to the annual convention of this association general statements as to the operating expenses of various plants—both arc and incandescent. This information should, of course, be received by the committee in perfect confidence, and should be used only for the benefit of members of the association.

There are many ways in which our interests might thus be promoted. For instance, it may appear that A, running a 300 light plant, has an expense of 2 cents per lamp per hour in the lamp department (repairs, globes, carbons and attendance); whereas that of B, with a business of like extent, amounts to 2, 3 or 4 cents, and, in the power department, A may be spending 3 and B but 2 cents per lamp per hour. The chairman would then direct A to confer with B in regard to power, and B to correspond with A in reference to the lamp department.

Unless some such method be adopted any treatment of the subject will be of little value, while with such a system reports could not fail of most important beneficial results.

UNDERGROUND WIRES FOR ARC LIGHTING.[1]

BY RALPH W. POPE.

The six months which have passed since your last meeting, although not productive of material progress in the burial of the wires, have at least been instrumental in bringing to the attention of the people generally some of the difficulties which are to be encountered in this work. Having arrived at the conclusion that the important subject of subterranean systems was practically confronting us, either for good or for evil, your committee was represented at all of the public meetings of the New York Commission on Electrical Subways which were held subsequent to its appointment. Over one hundred different plans were presented, out of which a very few were in actual use. As is generally understood, the supposed object of this commission was either to select, or cause to be devised, what is termed an inclusive system; that is, one which would satisfactorily accommodate the various descriptions of electrical service owned by thirty or more different companies in the city of New York. According to the generally accepted interpretation of the law, under which the Commission was appointed, its investigating duties were properly confined to the subject of conduits, through which the various companies are expected to lay such classes of insulated wire as they prefer. Among the vexed questions which continually cropped up was the inductive effect of the arc lighting wires upon those of the telephone and burglar alarm systems more especially, although none of the other interests appeared to regard them as desirable neighbors.

Among the proposed plans of providing for arc light wires were those of imbedding them in a solid prism of insulating material, the individual wires being either bare or insulated; running them through small individual ducts or small glass tubes; making them up in cables using various descriptions of insulation; but more commonly the individual wires were expected to be insulated, and covered with a sheathing of lead. In the latter form subterranean arc lighting wires are now, and have been in use for a considerable length of time in Chicago and Philadelphia. In practice there appears to be a difference of opinion as to the choice between a solid and a stranded wire. Where a single conductor is used the question is not of great importance, but where several conductors are grouped in a cable, it is necessary that each should be made up of strands in order to secure the requisite flexibility.

For underground work, especially cables, it is of vital importance that the conductivity should be ample and the insulation unquestioned. In both of these particulars it will be found most economical in the end to allow a safe margin. The value of a conductor when once placed in position is sufficient to warrant that no reasonable care or expense should be spared to provide not only against actual damage, but also the annoyance arising from interrupted circuits. It is here that the principal item of additional expense for underground work is to be incurred, for while wire suitable for aerial use in arc lighting costs but about two cents per foot, the price of insulated wire which may be safely put underground ranges from six to twenty-five cents per foot. Without going into the question of

1. Read before the National Electric Light Association, Baltimore, February 11, 1886.

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ditches, conduits, poles, insulators, etc., in order to obtain a basis for a proper comparison of prices, we are at once confronted with the stubborn fact that the wire alone will cost at least $300 per mile. The various circumstances which will govern subterranean construction in different cities will materially affect the cost of the work. Where conduits are provided by a company organized for that purpose a fixed rental will doubtless be charged, and the manner in which the space is utilized, and the number of wires for which accommodation is required, will have a most important bearing upon the cost pro rata of each circuit. In Chicago a 2¼ inch duct is rented for $500 per year, which, if required, will permit eight arc light wires to be drawn in, each being five-eighths of an inch in diameter outside. It is evident that in cases where individual companies perform their own construction the proportionate cost of each circuit is considerably reduced as the number of conductors increases. In such cases, also, the company doing its own work may choose its own method, while in dealing with a conduit company it is obvious that the facilities offered must be utilized. We have already pointed out the necessarily increased cost of the wire to be used for this work, and it is obvious to all that if by the adoption of a conduit which will permit the use of the lowest priced wire, without endangering either the property or the service, there will be a considerable saving in this particular. To accomplish this desirable result the conduit should be of an insulating material, and of sufficient stability to not only protect the wires from mechanical injury, but endure the ravages of time and the disintegrating effect peculiar to the soil, arising either from natural or artificial conditions.

While it may be perfectly practicable to insulate arc light wires from the possibility of earth contact underground, the difficulty and expense of doing so is materially lessened by the use of an insulating conduit. Upon this question there is an honest difference of opinion between different investigators, some of whom confine their attention to the requirements of the particular branch of service in which they are interested. It being the natural tendency of electricity to seek the earth, it appears wise if compelled to use subterranean wires to insulate them as effectually as possible at a reasonable expense.

To enter into the merits of the various proposed plans for this character of work would be beyond the province of this report, and invite discussion regarding features which would not be based upon the test of actual experience, and it is therefore confined to brief details of systems with which many of your members are already familiar.

A conduit of cast iron is now used in Philadelphia, through which arc lighting wires have been drawn for a system which has been in operation for over two years. Over 250 lamps are said to be used in connection with it. The conductors used are insulated with india-rubber, covered with braid and sheathed with lead, the outside diameter being half an inch. This conduit is built in sections, with shelves inside to accommodate different classes of wires, although used commercially for electric lighting only. No record is presented regarding the regularity of the service, but it is said to have been perfectly satisfactory. Man-holes are placed at the street corners in connection with the conduit, the wires being drawn through by hand as required. These man-holes are built up of cast iron rings, although in some cases it has been found necessary to construct them largely of brick on account of existing water and gas systems, which required a departure from the regular plan. The conduit contains upper longitudinal compartments, to which access may be attained through hand-holes which are located just beneath the pavement in front of each building. Any wire which is required for service at any building along the route is diverted at the man-hole to one of the upper compartments. With the use of an earth auger, connections are made by boring through from the cellar to the hand-hole, and inserting a sufficient length of gas pipe. Considerable difficulty was experienced by the accumulation and explosion of gas which leaked into this conduit, which is now obviated by driving a current of air through it.

The conduit system of Chicago, in which various arc lighting wires have been placed, is made of a special form of asphaltum concrete, originally devised for sewer pipe, and, according to the testimony of civil engineers who have carefully examined it, is practically indestructible for underground work, although it should be properly protected from the prolonged effect of extreme heat. This material is a good insulator, and it was this qualification which led to its availibility for subterranean electrical work. This form of conduit was referred to at your last meeting, and since that time has been introduced in Detroit, where an arc lighting system in connection with it was recently established, which is now in operation. Connections to buildings are made in Chicago by laterals leading from the man-holes at street corners to the vaults under the sidewalks or areas, as they are called in that city. There are no overhead wires used for electric lighting, neither is there any public street lighting by electricity.

In Washington, where the government authorities are forcing the electrical companies to place their wires underground, no inclusive system has been suggested, but each company is supposed to adopt such a plan as may best suit its requirements. This condition of affairs is liable to arise in cities which are subject to underground enactments, but in which the electrical systems in operation are not sufficiently compact to require a general conduit.

The plan adopted there for arc lighting wires consists of a wooden trough, in which insulated conductors are laid side by side, the wires being separated from each other by the use of bituminous bridges, which are placed about 18 inches apart. The trough is then completely filled with bitumen, making a solid insulating mass, impervious to dampness. With wires of ample conductivity, such a plan is no doubt permanent and reliable. The distribution wires are branched out in a similar manner. With a small number of main lines this operation is comparatively simple, and may be readily understood by examining the drawing herewith.

An estimate is appended giving the cost of a 60 arc light plant, arranged in connection with an underground conduit of this character one mile in length.

Your attention has been directed only to such underground work as has been actually accomplished in this country for arc lighting purposes, with a view to the accumulation of general information which may be of benefit in the future extensions of the industry in which you are engaged. The nature of the subject is such that there will necessarily be many conflicting opinions as to the proper course to be pursued, in which you will naturally be guided by a proper regard for safety, reliability, durability and economy of construction.

ESTIMATE FOR 60 LIGHT ARC PLANT WITH UNDERGROUND SYSTEM.

Building	$1,000 00
Engine and boiler	2,000 00
2 dynamos, lamps, etc	10,000 00
Underground conduit (one mile in length)	4,000 00
2 mains, 4 wires, including 60 connections, say	$17,000 00
On basis of capital, say	$20,000 00

Expenses of running plant would be:

LABOR.

1 superintendent	$2 50	per day
1 trimmer	1 50	"
Engine driver	2 50	"
75 carbons	1 50	"
Coal	3 75	"
Sundries	1 00	"
	$12 75	

If only 50 lights are used at 40 cents per night each, it will yield a revenue of $20 per night.

A revenue of	$20 00
Which will have cost	12 75
Leaving a profit of	$7 25
And taking 300 days per annum	$2,175 00

or equal, say, to 10⅞ *per cent. per annum.*

If 60 lights are used at 40c	$24 00
Cost same as 50 lights	12 75
Leaving a profit of	$11 25

or equal, say, to 16⅞ *per cent. per annum.*

PROGRESS IN ELECTRIC RAILWAYS.[1]

COMMUNICATED BY CHAS. J. VAN DEPOELE.

I APPRECIATE highly the honor you conferred upon me at the last meeting held in New York, in appointing me to make a report with regard to the progress made in the electrical transmission of power, and I only regret not to be able at present to give a more detailed account of what has been done. However, I shall endeavor to show that electrical transmission can be used with economy on ordinary street railways, doing away with horses or with dummy steam engines; and in the absence of other data at command, I will take the liberty to give you my own experience of the past few months if this may be acceptable to your honorable body.

During the summer months of 1885, I entered into a contract with the directors of the Toronto, Ont. annual exhibition, to run a train of three cars and a motor car, from the street railway terminus, to the upper grounds of the exposition, a distance of a mile. Having only a single track, I had to prepare there, for a light train and a good speed. The plant consisted of the following: One steam engine 10x16 running 125 revolutions per minute, driving an ordinary 40 light (arc) machine, having an electromotive force of about 1400 volts and an intensity of current of about 18 ampères. The engine and dynamo were placed in Machinery Hall, close to the boiler room.

The dynamo was connected; one pole with the rails, which were fastened together by means of fish plates, and the other pole to an overhead wire, hanging over the centre of the track, by means of arms extending from poles placed along the length of the track. On top of the car, on which the motor was placed, was a contact wheel carried by a pivoted beam, the latter being provided with a spring on one end pressing the wheel at the other end up against the underside of the overhead wire, this contact wheel being in communication by means of a flexible cable, with the switches, rheostat and motor. From the motor the current was carried to the axles of the wheels, and thence to the track thus closing the circuit upon the generator.

We began placing poles, etc., on the 1st of September, and made our first trip on the 5th of September. From beginning till end not the slightest hitch occurred, running regularly from 8 A. M. till 10.30 P. M. without stopping a minute. On many occasions we carried from 225 to 250 people. On one end of the track we had a 200 foot curve to start, then a level of some 2,000 feet—with two curves of about 1,000 feet radius, then a grade of some 1,500 feet, gaining gradually to about 6 per cent. The rest of the road had a downward grade up to the terminus, which made it a disadvantage in starting. As above said the distance was a mile and the round trip never exceeded 8 minutes, so including starting and stopping we made for part of the way at least 30 miles per hour. During the last five days of the fair we carried 50,000 people. The consumption of coal, as given by Doty and Sons, who ran the engine, was on an average of 1,000 lbs. in 10 hours.

The next step was at South Bend, Ind., where we equipped four ordinary street cars, one large open car with a 10 h. p. motor, and the other three closed cars, each with a 5 h. p. motor. The large car was run for the first time on November 14th, 1885, and was packed with humanity to its utmost capacity. Everything worked like a charm. The plant consists at present of the following: a 50 h. p. water wheel, and two 20 h. p. generators, and as above stated one 10, and three 5 h. p. motors. The track is laid with the ordinary flat rail, so in order to connect the rails together we placed copper plates 3″x12″ under the joints and spiked the rails down upon the copper plates, this was done on both sides of the track, so that there is no chance of breaking circuit. As will be understood the rails in the present case form again one part of the circuit, the other part consists of a copper wire ¼ inch diameter suspended above the track, from cross wires fastened to poles placed near the curbstone, and at a distance of about 100 feet apart. From the under side of this copper wire or conductor hangs a carriage, fastened to a flexible cable, passing to the inside of the car, where it is in connection with the switches, the motor, etc.; this carriage travels along with the car, and makes a perfect contact. After the first trial of November 14th, the 5 h. p. motors were soon in place and have worked admirably well. The tracks are never perfectly clean on account of constant traffic over the road, but since both rails are connected and also all four wheels, it is almost impossible to break circuit between the motor and the rails. The cars have run right along through mud and snow, and no trouble has been experienced with the circuit.

On running the four cars at once, the generators work perfectly, from 6 at morning till 11 P.M., requiring not the slightest attention, the brushes being set in the morning and not touched afterward. Every car works independently back or forward, without interfering with the others, and the division of the current leaves nothing to be desired. The only trouble we have encountered with the plant, has been with some small mechanical details, such as link belts breaking, etc. These of course being small matters are easily rectified. The main point here was the electrical part and this has proved to be an unqualified success. There is no wear to speak of, in the generators, and the same can be said of the motors. The motors are placed under the cars, between the wheels, and connected to the axles by means of link belting. At either end of the car is placed a dial plate fastened to the dashboard. Over one-half of this plate moves a handle directing the motion of the car either forward or backward. Over the other half is another handle, by which the speed is regulated. When full current is turned on, the maximum speed of eight miles per hour is attained, and this speed cannot be surpassed, six to eight miles per hour being the maximum speed allowed within the city limits on any ordinary tramway. The length of the present road is about 2½ miles. The other roads will be equipped as soon as the weather allows of the placing of the poles for the cross wires.

On the 6th of October, 1885, we entered into a contract with Mr. McCannico, president of the New Orleans exposition, to run a train of cars in the grounds, with a carrying capacity of from 180 to 200 people. This road is similar to the one in Toronto, nearly a mile long, running from St. Charles street main entrance, along the government buildings through the grounds, to the main building and Art hall. All was ready for operation for the opening day, but on account of delay in obtaining steam power, we only began running regularly on the 14th of December.

The generator is run by an engine 12x18, running 100 revolutions per minute. The generator is of 35 h. p. capacity, the motor being placed in the centre of an open car, only taking away the two middle seats, thus leaving the other seats for the public. Besides this there are two

1. Read before the National Electric Light Association, Baltimore, Feb. 12, 1886.

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more large open cars. The car containing the motor is provided with a contact wheel pressing up against the under side of the overhead wire, as in the Toronto road. This train runs regularly from 8 A. M. to 7 P. M., and has up to date proved a perfect success. The maximum speed is 15 miles per hour.

The heaviest work we have done so far, is in Minneapolis, Minn., and that during the winter months when snow and ice are faithful companions on the track—whether invited or not, they are there without fail.

Before undertaking the job I was very much afraid that electricity would not be practicable in a climate where the thermometer rises seldom above the freezing point for at least three months of the year. All my fears, however, have been removed in the past six weeks; we have ascended the grade and turned the curves with at least as much facility as the steam dummies. On one occasion the steam dummy brought us down to the road where we had our electrical connections. The steam dummy got stuck with our motor car and a large open car, the latter about fifty feet long; we dismissed the dummy, and as soon as we had current on, we furrowed our way through the snow and had the track clear in a short time. This proves that we could do at least as much as the dummy. A brief description of the track will give an idea of the work done by the motor.

Starting from Bridge square is a curve 60 feet radius. The road is then straight for about a mile, but raises and falls continually until 13th is reached. Here is another curve of 50 feet radius to the right. One block further is a similar curve to the left, the rest of the road straight, but continually raising up to 24th street, the top of the hill; the steepest grade is about 1500 feet long and six per cent; beyond this is a switch and the terminal of our present electrical equipment.

The electrical plant consists at present of one 60 h. p. generator and a 50 h. p. motor. Our circuit consists of the rails for one side, and an overhead wire, $\frac{3}{10}$-inch copper for the other side.

In South Bend, we have water power as the prime motor; we ran for the first time on New-years eve, 1885, and continued on New-years day. The water-wheel had no governor and we found it rather dangerous for the generator; as the water-wheel had to be governed by hand, it was impossible to keep the speed anywhere near constant. It was decided to put a governor on before running regularly. Several trips however were made over the entire length of the road giving entire satisfaction. The weight of motor is 3500 lbs., and the total weight of motor car or electric locomotive is eight tons. The passenger cars in use here are similar to those on the New York elevated roads. While the water governor was being made a steam engine with a 12x18 cylinder, 125 revolutions per minute was used, and although too small for the purpose, very satisfactory work has been done. In some instances we had three to four inches of solid ice on the track and broke our way through it without the least trouble. In a few days the water power will be in shape to run regularly on schedule time.

Thus far we have demonstrated that electric railroads can be operated anywhere, where the steam motor can go, and that there is much in favor of electric motors in cold countries, is very evident; there is no danger of pumps freezing up, nor of brakes becoming inoperative, no water tanks are needed along the road, nor is there any coal to be taken, in fact there are thousands of advantages in the application of the electric locomotive on street and other railroads. Whenever water power is obtainable the economy need not be disputed, and even in the case where steam is to be used as a prime motor, there will be considerable economy.

No cheaper nor better plant can be introduced to run light trains on suburban roads than the electric motor, as for instance on the Detroit road now in progress, connecting the latter city with Dearborn, a single train will be run with six large sized street cars. The speed will be from 15 to 20 miles per hour. The length of this road is nearly three miles, and it will be in operation in a few weeks.

A similar road will be in operation, early in the spring in Appleton, Wis. In this case however, six cars will be equipped with 10 h. p. motors and run independently. The length of road is about eight miles. The speed is to be about 10 miles per hour. Water power will be used to run the generators.

The street railway in Montgomery, Ala., is now being equipped with our motors, 12 cars in all, and will be running within 30 days.

In all the above places we are using overhead conductors, which are no more of an obstruction than the ordinary telegraph and electric light wires, in fact much less since the conductors are over the centre of the roads; so wherever wires are allowed for other purposes, they cannot be refused for this use. I do not believe, however, that overhead wires would be practical in large cities where other wires have to be buried; but in this case the electric conductors can be placed underground in conduits similar to those used for cable cars. This will be much more expensive than the overhead conductors, but it will be a permanent and practical fixture.

I regret that I have not found more time to prepare some figures with regard to tests of motors and general transmission, but the above is a resume from practical experience and facts on the track instead of on paper. I am a solid believer in the saying that 'experience is the best teacher', and to all the above I have attended personally from beginning to end, and am more than ever convinced that the electrical transmission of power has ceased to be ephemeral, but has become a real fact and a blessing to the world. All is ready, it has only to be applied judiciously and success is eminent. Thousands of horse-power are now running waste in our water falls which can all be utilized to advantage, in some cases running our tramways, in others our factories, etc., giving at the same time light and cheer during the absence of old Sol.

MINNEAPOLIS, MINN., February 7th, 1886.

TRANSMISSION OF POWER BY ELECTRICITY.[1]

BY A. F. UPTON.

AT the electrical convention held last August in New York city, in a paper I had the honor to read at that time, in speaking of electric lighting stations, the following remark was made: "One thing occurs to me, which I think electric light companies should take into consideration, and that is the letting of power. At the Edison company's station, Lawrence, Mass., a large number of Sprague motors are used which run all day. They use from half a horse-power to five horse-power each. These Sprague motors are all employed at a good profit, and it has always seemed to me that every electric light company should use their power in the day time to run small machinery. You have it in your stations, why not use it?

Since then, information on this subject has been sought in every way and from all available sources. Electric power, in many places, has for some time been sold from central stations, just as steam power is sold, and with profit to both seller and buyer. In Boston this has been done by the Daft Electric Power Co., using the Daft system, and considerations of the results here attained will suffice to show the commercial value of electric transmission. Dynamos are run by an Armington and Sims company's engine at a central station, supplying electric power to about 30 motors in various parts of the city. It is sold at $150 per horse-power per year, the price at present being about the same as that for steam for small powers. It is a curious

1. Read before the National Electric Light Association, at Baltimore, February 11, 1886.

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circumstance that more power is sold than the engine can supply,—a paradoxical state of affairs explained by the fact that scarcely any set of machinery is kept running steadily, and the company supplying power gains by the stoppages. At this station they have in use two Daft dynamos of 25 h. p. each that are run by being belted direct to a 50 h. p. Armington and Sims engine. The steam is generated in a steel tubular boiler set with the Jarvis furnace, and coal screenings are used for fuel. This power is transmitted all over the city, and is used for running all kinds of machinery, including sewing machines, ventilator fans, printing presses, elevators, and other work. The demand for power far exceeds the supply, as the company has let all the capacity of their engine, and have applications for 300 h. p. more It is the intention of this company to start a large central station to be run exclusively to let power. The present plant has been in operation over 18 months, and the only interruption has been three hours, when other parties cut their wires by mistake. In many cases these motors have supplanted small steam engines, gas engines and hired power. Customers claim that the power is more regular than they have ever used before, even when coming from the adjoining buildings. There is in Boston one engine running 29 elevators ; if every elevator was used at the same time the engine would not have over one-half the required power.

LOSS OF POWER BY TRANSMISSION.

From all the information gained, the actual loss in the process of conversion of power into electricity, and transmitting power from the dynamo to the receiver, amounts to about 40 to 50 per cent. The manufacturers of the dynamos claim only a loss of 30 to 40 per cent.; but it is a safe calculation to allow a loss of one-half. This, as has been explained, is more than made up by the excess of power that can be actually sold and paid for. Electrical transmission has the unparalleled advantage of being superior to the obstacle presented by distance. Then, again, it operates its miracles in perfect silence and repose. No force appears in the wire such as appears in shafting, in pipes with compressed air or water, in endless chains or belts ; and, in case of powerful currents, insulation is easy. The conductor can be bent or shifted in any way while transmitting many horse-power, provided, of course, its continuity be not interrupted. It can be carried round the sharpest corners, through the most private rooms, into places where no other transmitter or power could possibly be taken. There is nothing to burst or to give way. In short, such a method of transmission is the acme of dynamical science. At the present time steam is the foundation of electrical power. Water power is unsteady and not reliable ; gas motors are of limited power. With improved steam engines, belted direct to dynamos and the Jarvis process of utilizing low cost, waste fuels, the cost of making power has been reduced, within the past few years fully one-half.

ELECTRICAL RAILWAYS.

The most important use to which the principle of electric transmission of power is at present being put, is the running of street railways. It was only a little over five years ago that the first electric railway was built in Germany, and to-day there are many in that country where their practical success has been demonstrated. In France and England they are fast becoming popular, but it seems that those in America are yet almost of an experimental nature; in this branch of electrical science at least, America is far from foremost.

The advantages of electricity over steam for railway purposes are many and great. In the first place the bulky locomotive is done away with, as the electric motor can be placed either under the car or on trucks by itself ; in either case great weight and room being saved. The machinery for converting the coal into the power, or rather extracting the power from the coal, is not portable, but stationary, and can be placed in the most convenient spot. For transmitting the power in many cases no difficulty has been experienced in using one middle rail as the conductor. Sometimes it has been found that the dirt sticking to the rails and the wheels formed a sort of crust so insulating as to prevent adequate communication. From all the information I can gain on this subject it is my opinion that the most practical way will be to use wires on poles. I understand this system is used in the west by the Van Depoele company. The poles can also be made available for stringing electric wires for both incandescent and arc lighting. The future of this system is filled with possibilities. It will eventually become the motive power of all the present horse railroads. In a few years elevated electrical railroads will be as plenty as steam railroads are now, and in time it will supersede the present system of running locomotives on all railroads,—and why not? It is simply a question of cost of making power. It is acknowledged by every practical engineer that the present system of making steam in locomotive boilers is expensive as well as wasteful. The evaporation of pounds of water to each pound of coal consumed to make steam in locomotive boilers does not average over three and one-half pounds of water, using the best grades of bituminous coal, while with stationary boilers set to burn coal screenings for fuel, an evaporation of nine pounds of water to one pound of fuel is made, and the reduction in cost of fuel is from one-third to one-half. It is only a question of time when all the different electric lighting stations in this country will use their engines in the day-time to make power to be sold for manufacturing purposes, the same as they sell power in the form of electric lights now. They can also furnish power to run electrical railways, elevated or surface. The economy of this system over the cost of running horses, as used now, will be over 50 per cent.

SPEED.

As to speed, it is impossible to give the limit which can be reached on electric railways, because those so far constructed are on streets or in localities where very rapid transit is not possible or desirable. On the very first one built, a rate of seven miles per hour was customary. On the Berlin railway, opened in 1881, the greatest speed reached was at the rate of 18 miles per hour. More was possible, but the police authorities refused to permit more than 9 miles per hour. Up to August 1882, there had been no breakdown on this road. On the Siemens railway, at the Paris exhibition of September, 1881, a distance of over 1600 feet was traversed in a minute, which is at the rate of nearly twenty miles per hour. There is every probability that electric locomotives can be run faster than any steam locomotive now in use. About ten miles an hour is the average speed that a car can be run on an electrical street railway, but I think it is possible to run at the rate of 100 miles an hour. In the near future, on elevated railways, this will no doubt be accomplished. I believe the time will come when cars will be run by electricity between Boston and New York in about two hours time, where it now requires six hours by steam railroads. We Yankees call ourselves practical people, we believe in the success of the use of electricity for elevated and surface street railways ; believing this we propose to put it into actual practical operation. Petitions are now before the present legislature of the state of Massachusetts for charters for over a dozen street railways, part surface and part elevated, all to be run by some system of electric motors. In Massachusetts a horse railroad can be started under the general law, but as the law stands now an electrical railway requires a special charter. A petition has been presented asking for an amendment to the general law and allowing electrical railways to be started the same as horse railroads are started now. We believe that the cost of power as compared with the present cost of using horses will show an economy of over 50 per cent. In the town of Winthrop, Mass., near Boston, sufficient money has been subscribed

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for erecting an elevated railway, on the Enos system, to be run by electricity. The station will be constructed so as to include the use of dynamos for electric lights, and the elevated railway will be utilized for stringing wires to run them. If the charter is granted, work on this railway will be started at once. The plans are all made for an electrical station three stories high, the upper stories to be used as a manufactory, and power supplied from the station below—a most profitable way of utilizing the power of electric light stations in the day-time.

POSSIBILITIES.

The electric station of the future will be erected to utilize power in hundreds of ways not now thought of. Central stations should be made large enough to combine all the present methods of using electricity, with full allowances for future discoveries, for I believe electricity is in its infancy. By this strange and novel agency power will be used to do its share towards the support and advancement of the human race. We may yet know, in our time, what electricity is, for to-day we only know it is a power that shows itself by its manifestations.

A professor in a college asked a student one day what electricity was. The student hesitated and tried to think of the correct answer, but in vain, it was of no use, he could not recall it; but in self defense said, "I did know but have forgotten." The professor replied, "This is terrible, the only man who ever knew what electricity was, has forgotten the answer."

Electric light and power stations will be erected in the future as large as our present cotton mills, the engines will be used in the day-time to run lines of shafting to furnish power for manufacturing purposes over the station; power motors will transmit electricity all over our cities to run small machinery. Both arc and incandescent lights will be used. Perhaps storage may yet be a success. Electricity will be used to drive machinery, to produce ventilation, for heating purposes, the exhaust steam will also be used for heating neighboring buildings in cold weather.

There is no need to expatiate upon the advantages to be gained from an economical method of transmitting power; the costly and persistent attempts of inventors and capitalists to get better methods are enough to prove their desirability.

Many systems have been tried and found wanting. In electricity, thanks to living inventors, we have a force into which power can be transferred as by the wave of the magician's wand, a force which flows to any distance with rapidity of lightning and the stillness of a ray of sunlight, and then at bidding, resumes its original shape quicker than thought can follow it.

THE RELATION OF ELECTRIC LIGHTING TO INSURANCE.[1]

BY C. J. H. WOODBURY.

THE competition forcing the struggle for existence in modern civilization is not shown anywhere in a more marked degree than in the demand for time. Like the dying royal reprobate, it cries, "Millions for a moment of time," and seizes upon every expedient which will add to the measure of time at its disposal.

Rapid transportation in shortening unavailable time, and artificial illumination in lengthening available time, minister to the necessities of commercial and home life, and form our greatest industries. Transportation requires more capital than any other industry, about 20 per cent. of the live capital of this country being invested in railroads. The several methods of artificial illumination and their kindred industries are second on the list, requiring somewhat over 2 per cent. of the invested capital.

Both of these subjects have received the careful attentions of legislators, and these interests have reached such magnitude that the most carefully-phrased legislation has been enacted to defend the individual against the undue exercise of corporate power.

The numerous and continuous injuries to person and to property, in spite of all precautions, have caused the most stringent statute laws relative to the production of artificial light. Although differing in the several states, all relate to similar measures, such as: oils for illumination must exceed certain fire tests, must be stored in covered buildings, cannot be left near the highways; and numerous regulations control matters relative to transportation and sale, and also to its use on railway and coast and internal marine lines carrying passengers at night.

The varied legislation in respect to burning gas, fixes minimum limits as to luminosity, percentage of poisonous gases, the rights and responsibilities of gas companies in the franchise permitting them to enter upon and open highways; and one state, at least, possesses a law which can be construed as forbidding a gas meter operating as a perpetual motion.

This class of laws has been a necessity in the endeavor to reduce the casualties resulting from the use of artificial light; and, wide as they are in scope and exact in details of enforcement, the painful consequences following the use of oil and gas show that these laws fall short of their purpose.

At this time we have occasion to consider only one of the several methods of illumination, and it is remarkable that electric lighting which is in general use throughout the country, and containing, like all other forms of energy, well-known possibilities of danger, has never been the subject of any state law yet in force. City ordinances have been passed for a purpose, and to no purpose. The questions of the safety of electrical illumination have thus far been settled by the electric interests without intervention of the law; and I venture to state that the instance of an industry voluntarily assuming its self-government for the direct weal of other interests is without parallel. When electricity was first applied for illumination on a commercial scale, it was a business without precedents; everything was new, crude and undeveloped. The leading inventors were absorbed in the solutions of their problems; no trained assistants were available; the books contained nothing on the modern application of dynamo currents; the scientific schools could teach but little except general principles; telegraphy had but little in common with the subject beyond its terminology; so that neither technical graduates nor telegraphers were prepared to enter upon the work without further training. Mechanics had much to learn in the matters of construction of apparatus; the proper manufacturing supplies were not in the market, and the best steam engines for meeting the conditions for the best operation of dynamos have appeared since that time. The development of the whole business required invention, education and organization from one end to the other.

Considering the nature of the difficulties which were surmounted, the wonder is not at the mistakes, but at the success.

One of the elements naturally disregarded at the outset in the rush to invent, make and install the apparatus, was the possibility that electricity might like other methods of lighting become a cause of fire.

Soon numerous fires served as a reminder that electricity as applied at that time possessed no immunity from consequences similar to those resulting from other methods of illumination, and public opinion for a time had a tendency to veer to an extreme position—even farther from the truth than its first assumption that electricity could not produce a fire.

A careful examination of the circumstances attending a number of these fires, and a repetition of these conditions upon electric lighting plants, served as the basis of the

1. Read before the National Electric Light Association, Baltimore, February 12th, 1886.

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regulations for the use of electric lighting apparatus prepared by the writer for the Factory Mutual Insurance Companies, a little more than four years ago. It would have been impossible for the work to have been carried on, had I not received the most cordial co-operation from the electric light companies; and the electricians at the head of these companies freely gave of their experience, in the endeavor to determine the facts at issue.

The results of this work warranted the opinion that a well arranged electric lighting plant was the safest method of illumination, and the experience of time has sustained that position.

The essentials for safety in an electric lighting plant are few and simple. In the presence of combustible material, arc lights should be enclosed in globes resting on closed stands with a raised edge, confining the sparks and copper, and some extra stop at the bottom of the lamp to prevent the lower carbon from falling in any contingency. The feeding apparatus at the lamp should prevent the formation of an undue arc in case of any disarrangement. Switches should be constructed so that an arc could not be formed by their use. The electricity must be confined to its metallic circuits and the conditions of its use controlled.

The regulations found necessary to specify these particulars in detail are of some length, but do not embody any other features. Experience has shown that they have served the purpose for which they were intended, for I do not know of any fire from electric lighting apparatus except where they have been violated.

The chief elements of danger are conductors of high resistance, generally formed by two earth contacts, and sometimes by a conductor between two wires of different potential. Such diversions of current are generally caused by water penetrating the insulation, and it is of importance that the insulation be waterproof, wherever there is liability of exposure to moisture.

The enforcement of these rules by the Factory Mutual Insurance Companies and the Boston Fire Underwriters' Union was based upon an inspection which was recorded upon the following blank, by underlining the items to be specified; spaces are left for negatives and the addition of notes of a more general nature; further remarks can be written on the other side of the sheet, where it is dated and signed by the inspector. Attention is called to items requiring correction, by an X in the margin.

For inspection use, these blanks are secured by rubber bands in a small portfolio the size of a pocket note book, and after a record has been made upon them, they are filed away at the office.

Careful attention should be given to the importance of daily tests for ground connections, and for this purpose an ordinary Bell magneto is the most convenient apparatus. The electric bells and small galvanometers, with low resistance coils frequently used for this purpose, are not sufficiently delicate, as they cannot indicate a weakness in the insulation unless its resistance be less than ten to one hundred ohms according to circumstances.

The general average of electric plants have no place for the expensive apparatus and methods necessary to measure the resistance of the insulation of the system. Whatever method may be employed for permanent testing, the line connecting the electric light circuit with the testing apparatus and thence to the earth should have a spring switch, which can not be left closed, and thereby ground the circuit.

I have used for several years the portable magneto which I devised for the purpose of inspection testing. The shaft of the driving pulley is at right angles to the armature, and this allows it to be placed in a small flat rubber case, which contains two flexible steel reels each 30 feet in length, which serve as conductors between the circuit and the earth.

The value of this method of inspection which I have described is shown by the results following its adoption. In the autumn of 1881 and winter of 1882, 23 fires were caused by 61 electric lighting plants in mills insured by the Factory Mutual Insurance Companies in the eastern portion of the United States. The apparatus was inspected and the alterations necessary for safety, specified and carried into effect, and there has not been a single fire from electric lighting apparatus on this property since that time, although the number of mills using electric lights has increased to nearly 200, and the average size of the plants greatly enlarged. From being a legitimate cause of apprehension on the part of the underwriters, the hazard of electric lighting, in this field at least, has subsided into a matter of routine inspection.

There is a prospect of new matter at issue, which will tend to reverse the present conditions relative to safety in connection with the distribution of electric lighting. There is a widespread feeling of opposition to aerial electric wires, and several city governments, with the intrepidity of practical politicians, have passed ordinances decreeing that the wires must be buried.

In the present state of the art of supplying arc lights from central stations to scattered clients, the execution of such measures, if rashly entered upon, would be simply prohibitory, depriving the public of the enjoyment and protection derived from thoroughly lighted streets, and limiting its use to those who have boiler, engine and complete electric lighting plant on their premises.

It is well known that the use of all underground electrical conductors is attended with special difficulties. The first transatlantic cable resulted in a failure through the efforts to operate it in a manner similar to a land telegraph line; the telephone companies have concentrated their best forces upon the problem, with indifferent success; the telegraph companies have not been idle in looking out for their interests in the matter, and one of them has been engaged in experiments upon underground wires for several years, without obtaining satisfactory results. The telegraph system, as Prof. Morse invented it, did not contemplate other than underground wires, and aerial wires were put up as a matter of necessity, where it was impossible to bury them, on the stone viaduct of the Baltimore and Ohio railway, at Relay Station, and the nine miles of wire buried along the right of way of the railway between Relay Station and Baltimore was abandoned, because the insulation could not be maintained, and an aerial line substituted along the whole distance. On this occasion it is necessary to confine the consideration of underground wires to conductors of electric lighting currents, as being the only phase of the question germane to the objects of this convention.

Mr. Edison, with his inventive skill, supplemented by the immense financial resources of his company, has designed and laid a system of underground conductors for incandescent lighting from central stations distributing lights over a small area in the denser portions of cities containing his stations. It serves its purpose, which is to conduct electricity at a tension of one-thirtieth of that used on some arc lighting circuits. An insulation of sufficient resistance to be adequate for incandescent circuits would not be suited for arc lighting conductors. Mr. Edison invented that system of underground conductors for the specific purpose of adapting it to his system of electric lighting, and relatively simpler, as such a matter may be, than the invention of a feasible method of burying arc lighting wires under the present limitations of consumption, it may be noted that no other incandescent electric lighting interest has made any installation of any method of underground conductors. Portions of his central-station circuits are above ground, as is the whole of his "village system" of lighting, and his "municipal system" is not only above ground, but uses electricity at an electromotive force of 1,000 volts.

The distinctions between the conditions involved in the

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general problem of underground wires, and those of an incandescent system feeding a limited territory, have been stated, in order that this specific case may not be cited as a reason why all electric wires could be treated in a similar manner.

Like all parts of an electric light system, the conductors, whether aerial or subterranean, must be insulated from connection with the earth. For underground wires, this substance must possess a wide range of physical properties, in addition to high electrical resistance; it must be uninjured by extremes of moisture or dryness, or variations of natural temperature; it must not be acted upon by sewage or coal gas; not rendered defective by strains due to settling of buildings or the impact of traffic; furthermore, it must be cheap.

In all other forms of electric apparatus, a fault or leakage is merely an interference to the operation of the system, but in electric lighting a fault includes all this, and the liability of as much injury to person or property as may be possible by the amount of energy diverted from the circuit.

The clothes-line system of overhead wires adds no beauty to the landscape, but that is no valid reason for its abolition, except to those adherents of Ruskin who may endorse his fierce diatribe against the railway system as destroying the beauties of natural scenery, by 's cuttings and fills, its nerve-thrashing noise and black belched smoke, and above all, the utter absence of lines of beauty in either road-bed or rolling stock.

The few instances where wires over buildings interfered with ladders of the fire department might have been avoidable by the further elevation of the wires or by their crossing the streets at nearly right angles. In the natural course of improvement the lines in cities are being changed from their scattered courses, and systematized upon permanent fixtures high enough to carry the wires a reasonable distance above all roofs. Aerial wires certainly furnish the most ready means for electric companies to reach their customers, who are frequently distributed very unevenly over a city, and like all other seekers after trade, may at times conflict with other interests.

The network of wires over cities serves as the most efficient protection against lightning, these conductors, by their great number, scattering the force of thunderbolts and conducting them to earth; on this account thunderstorms are much more destructive in the country than in cities.

As for personal danger, a lineman is in infinitely more danger from gravity than from electricity.

I repeat that most of the fires from arc lighting systems have resulted in the diversion of the current by two contacts, one of them being a ground which had existed for an unknown time, and the second being an accidental ground, generally of increasing resistance until it converted the electricity into heat whose temperature was high enough to ignite combustible material. When a ground exists anywhere on a circuit, this ground is trying to form a second connection at the weakest point in the insulation anywhere on the whole circuit, irrespective of position. The one connection to earth may exist near the dynamo and the other in some building at the extreme portion of the circuit, or it may be only a few inches away.

When the conductors are secured to elevated supports, they can readily be kept free from all such earth connections, and a casual inspection shows the places liable to defects, and the necessary changes can be made. With an underground system, this danger exists everywhere along the line, and is difficult of location and remedy, while the natural deterioration of material renders the hazard an increasing one.

The agitation of the subject has stimulated inventors, and the protection of the Patent Office has been invoked accordingly upon divers methods of covering and grouping wires to be laid in a trench, most of them devised on the Mede and Persian principle, inasmuch as whence once laid away further changes would be unfeasible.

Many underground arc-lighting circuits have received faithful trials without obtaining satisfactory results which would warrant their adoption by any form of American practice.

In this connection, I wish to cite several instances where such trials have been made. A large contract for lighting a park was offered to an electric lighting company, upon the condition that the wires be placed underground. An electric light company in Boston made preliminary experiments by laying 1,200 feet of one of their circuits underground. The conductors consisted of number four copper wire covered with rubber insulating composition one-eighth of an inch thick, and further protected by two thicknesses of cotton braid. The two wires of the loop were laid in grooves, a foot apart, in a plank laid three feet below the pavement, and covered by another plank. The resistance of the insulation of this circuit exceeded 90,000,000 ohms when first laid, but it diminished until the repairs made necessary by the frequent escapes, became so burdensome that this underground line was abandoned, and a different line laid in a wooden conduit, with cleats arranged so that the wires could not approach nearer than a foot to each other. This second line consisted of the same size wire covered by a rubber insulating compound and inclosed in a lead tube; and this wire, like the former one, proved a failure in the course of a few months.

The faults were caused by a disintegration of the insulation, entirely different from anything similar resulting from the use of the same kind of insulation above ground.

At these places the wire would become vaporized and attenuate, similar to a pair of arc-light carbons, the connecting filament becoming smaller until an open circuit was established.

In Philadelphia, the escapes from an underground system of electric arc-light wires on Chestnut street are believed to have been the cause of several severe explosions of illuminating gas leaking through the ground. On Delaware avenue, in the same city, an underground circuit with different insulation, received a careful trial, until the escapes through defective insulation in spite of numerous repairs, diverted so much of the electricity from the circuit that the lights could not be maintained, and aerial wires were substituted. The temperature of these escapes was so great that the sand was partially fused in places, and if the lights had been inside of buildings, there would have been a liability of such points of excessive heat occurring in the presence of combustible material, with destructive consequences.

The result of a few weeks' experience with a short underground circuit is no measure of its capacity to fulfill the requirements necessary for central station arc-lighting, as it requires time to develop the faults in such conductors.

Aside from the question of overwhelming cost, there is no opportunity in cities to lay down subways without such serious interference with gas, water and steam pipes, and sewers that it would make their construction unfeasible. An underground circuit must be either a buried conductor or wires run through a conduit of small dimensions.

The insulation of buried conductors from those of Prof. Morse, in 1843, to the present day ,has not been sufficiently permanent to reach satisfactory results, although such cables have given excellent results on submarine work, where they are free from many of the severe conditions imposed on them by underground service in cities.

It is clearly essential that the insulation upon wires in conduits must be supplemented by the material of the conduit, also serving as an insulator.

In the oft-quoted subways of Paris, the wires are not in contact with the walls, but are attached to insulators

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fastened to beams, placed transversely across the subway, or against the walls, and are therefore suspended lines, surrounded by an insulation of air.

The use of underground systems would add to the obstructions of opened streets, increasing the measure of annoyance and danger arising from excavations in the highway, a difficulty which will increase in time, whether lines were successful or not, for if successful, the increased patronage would require additional wires; and, if unsuccessful, the constant repairs and alterations, in the hope of obtaining satisfactory methods, would require certainly more occupation and interference with the highway.

Admitting each statement alleged against overhead wires, there would still remain the fact that the experiment of underground wires involves dangers and difficulties that should not be rashly entered upon, lest, like the discontented frogs in the fable, king stork takes the throne of king log.

In conclusion, it may be said:

1. That the present application of electricity forms a relatively safe method of lighting.

2. Underground wires conducting lighting currents contain elements of serious danger in proportion to their defects of insulation.

3. The compulsory burial of all electric wires would be oppressive to the electric interests.

Our methods of life are so closely interwoven with the uses of electricity that we are dependent upon its applications, especially to transmission of speech, telegraphy and illumination, and any interference with the legitimate exercise of those interests will not be measured by the impaired value of plant or load of excessive expenditures, but will be a detriment to each member of the community now benefited by its use.

THE INCANDESCENT LAMP.[1]

OTTO A. MOSES, PH. D.

Mr. President and Gentlemen of the Convention:

I HAVE not prepared a report on the subject of incandescent lighting, but I would be very glad, in an informal, extemporaneous way, to mention some things which were not embraced in the paper by Mr. Beane, and which probably have not been presented in any publications that have appeared so far. What I propose to give is a little of the inside working of the incandescent light. I am a great believer in the doctrine our president has announced as the one which should prevail, namely, that we are here for the purpose of giving and receiving information. Ours is not a mutual admiration society; but it is one in which what we have we give; and I come to give that which I hope will be well received, particularly as it is a free gift.

Incandescent lighting, as you know, has been advancing ever since the time of Sir Humphrey Davy in various periods of development. He was really the discoverer of the incandescent light, and he produced some results with it that to-day would be extraordinary if witnessed. For instance, he used batteries of over 1,800 volts intensity. That would produce, in carbons of the thickness then used, results that would be perfectly overwhelming, and it astonished his audience, one of the most brilliant in England. After Sir Humphrey Davy, Starr commenced his experiments, and had he not died at the early age of 27, it is very likely he would have brought the incandescent light to a point where it would have been ready for adoption when the dynamo machine was invented at a subsequent date. Then there was another period, that of Boulyguine, Konn and Lodyguine. They used in St. Petersburg incandescent lamps for actual illumination. One of those gentlemen (I forget which one) was a merchant who was interested in scientific subjects, and he devised this lamp and put it in his store, and it brought a corresponding increase of business to him. People from all parts of the country visited him, and his lamp was thought worthy of honorable mention by the French Academy of Sciences. After that, Moses G. Farmer and W. E. Sawyer began to work on the incandescent light—both Americans. At the same time Swan, in England, appears to have made certain experiments on incandescent lighting in vacuo. But all these experiments were not much in advance of what Sir Humphrey Davy had done fifty years before. In 1865 incandescent lamps had been used for scientific purposes. They had also been used for mining purposes; so M. de Changy says. But we have nothing to substantiate that statement. During the Paris exposition he had an admirable opportunity to bring his electric light before the world, but he neglected it. I believe there is a legal maxim that if one neglects a right he forfeits it. At any rate, he brought out a paper in which he claims this thing, and figures the lamps exactly like those now in use. I took occasion to investigate his published claims, and I found, as I say, that they are not substantial.

After that period we come to the new one. Thomas A. Edison, assisted by a number of co-laborers, took up the subject of incandescent lighting, and in a couple of years brought it to a state of great development and perfection. Swan again took up the subject which he had neglected for a number of years, and commenced to work in that direction, assisted by several persons. Mr. Crookes also began to study the matter. His previous information, and what he had already done, enabled him to do that with the best grace in the world; because, had it not been, I think, for the investigations of Mr. Crookes, incandescent lighting to-day would not have been in the position in which it now is. Mr. Crookes, as you know, is a very able scientist, originally a chemist, but a man of multifarious development scientifically. In 1878 he made an elaborate study of gases in vacuo, and, in connection with a colaborer, Mr. Gimingham, a glass-blower, did a great deal to render incandescent lighting possible; because all the preliminary facts connected with the study of the vacua were carried by them to a finished point of development. For instance, he was enabled to produce vacua of one two-millionths of an atmosphere. As some one has remarked, that is equivalent to saying one one-hundredth of an inch of mercury in a barometric column three miles high. That will give you some idea of the perfection of the vacua that he produced. Contemporaneously with Mr. Crookes, Mr. Gassiot, Mr. Spottiswoode and Mr. De la Rive, all assisted by wealth, carried their investigations to a very high point of refinement. You know Mr. Spottiswoode had an induction coil made that would give a spark 40 inches in length, and Mr. De la Rive made use of the most complicated apparatus for producing all degrees of perfection in the vacuum, the eliminating of certain gases, the absorption, for instance, of oxygen and carbonic acid, and all those refinements which are necessary if you wish to study the phenomena in their perfection. After that Mr. Edison commenced his investigations, and still further perfected the mechanical parts of an incandescent lamp. His lamp was at the Paris exposition, and there found much favor. At the same exposition were the lamps of the United States company (the Maxim lamp) and those of Mr. Swan and Mr. George St. Lane Fox. However, the incandescent lamp was simply a matter of progressive development, it being already in existence. Sir Humphrey Davy showed that it could be produced by the incandescence of small carbon rods, made from vegetable fibre in the vacuum of an air-pump. Starr had done the same thing over mercury. Boulyguine, Konn and Lodyguine had done it by the use of stoppers. That is they had made vacua and had tried to stop them with cements. At that time Geissler had made his vacuum tubes in which

1. An address before the National Electric Light Association, Baltimore, February 12, 1886.

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he had rarified mediums; but his vacua were maintained by the fusing of glass, so that they were practically perfect. And, as an interesting fact, I may say that a vacuum tube was prepared by Prof. Quincke over twenty years ago, and he has been weighing that tube at intervals since, and it is exactly to-day in the same physical condition in which it was then. It is simply a glass vacuum tube fused off; so that the fused globe having a vacuum inside will absolutely not leak.

Every vacuum tube prepared to-day does leak, and it leaks because platinum wire is not glass, and there is an air film between, but that film is so infinitesimally small that probably it would take a hundred years before it would leak; that is, before it would become subject to the same atmospheric pressure that prevailed around it.

To those who desire to take up that subject, or who have been engaged upon it and would like to improve in it, I would say that the opportunities are considerable for the development of incandescent lighting. I would like to call the attention of members of the convention to particular points capable of development, so that they may work out on those lines—such lines as I myself have selected to follow up. As an exemplification, however, of what an incandescent light is, I have introduced this (exhibiting a lamp) at the request of the president. This is a lamp I have been at work on for several years past, although the principle has been applied by me long before. The lamp as you see it here—any lamp would answer the same purpose—consists of the following organs: A glass globe evacuated, either hermetically sealed by making it a continuous glass globe, or not hermetically sealed, and stopping it. In this case my lamp happens to be stopped with the only material that will not allow of admission of the atmosphere into it. That is, as you are well aware, platinum. The lamp that I have in my hand is a stopper lamp. However this stopper is of platinum. And I would like to call your attention to a very remarkable fact which enables incandescent lighting to be possible, which is this, that platinum and glass have identically the same coefficient of expansion. That is, if I heat a platinum wire and a glass rod of the same dimensions and observe the dilatation, I will find they have increased exactly the same in length and the same in width. You put these two substances together, and you have, under the applications of heat, the same expansions. And here comes another very wonderful thing for which we should be very thankful: it is that platinum is a very poor conductor of heat; so is glass. If those two substances, having the same coefficients of expansion, expanded in different times in different ratios, it would not be possible to unite them together. It is only because they expand in the same ratio that you can apply a surface of platinum to a surface of glass and get a perfect stopping for a vacuum. I do not know in the whole range of sciences where I can point to a fact where so much depends upon one trifling circumstance.

The next organ is the incandescing portion of the circuit which is enclosed in that vacuum. A little recapitulation here will be necessary. As stated, Sir Humphrey Davy already used carbon for that purpose. But platinum was known too. All the eudiometers that were used for the explosion of gases in vacuo, in the analysis of gases, contained platinum electrodes. Then platinum was used as an incandescing conductor. In 1864 I had the pleasure, as a student, of making eight incandescent lamps grouped in one fixture. The object originally was purely scientific, though practical in its bearing. It was to make use of the incandescence of platinum for the purpose of indicating variations of movement. I applied it to an anemometer, and I have the pleasure of saying that it met with the approval of the eminent astronomer M. Le Verrier, to whom it was shown at the astronomical observatory in Paris. Staite found that iridium was better than platinum in incandescent lamps, for certain purposes. Then came the period of carbon taken up by a triumvirate of Russian physicists, and also improved very much by Mr. Sawyer, who died some years ago, and then further developed by Mr. Edison. It is scarcely necessary to say that almost any organic substance will furnish a carbon that can be used for electric light purposes—all except those which have nitrogen in their composition. It is said that silk may be used for incandescing conductors. Experiments I have made show that silk disintegrates under it and forms flocculent scales. You can change the character of it by eliminating the nitrogen, and it is probable that has been done by those who may use it. But almost all organic substances will furnish a matter for the incandescing part of the electric light circuit. Carbon, as you are aware, has wonderful electrical properties. It will permit of the passage of currents very easily, and it is very homogeneous. That is, for given lengths it retains its resistance, uniformly but there is this one property that must be called to mind, that by increasing increments of heat in the preparation of the carbon you can diminish its resistance. A metal heated returns to its original resistance approximately, though some of them expand more than others and do not retain their original diameters, but with a very small degree of variation. You must look to something in the chemical nature of carbon for the cause of its peculiar action. I have examined the spectrum of carbon incandescing loops up to the point where they have disappeared under the strong influence of powerful currents; that is they have been volatilized, and I find that invariably hydrogen is present in the spectrum up to the last point of separation. As I said to M. Dumas, who was the greatest authority on the subject of carbon of this century: "I do not believe that such a thing as carbon exists;" and he replied, "I have very grave doubts of it." But carbon with infinitesimally small proportions of hydrogen may be called carbon. The diamond is probably the purest form of carbon that we have, but below the diamond in the scale of hardness I think you may say that carbon is always invariably united with hydrogen, and one or more atoms of hydrogen will continue to go off with every increment of the heat you give it, until the proportions become overwhelmingly carbon and infinitesimally hydrogen. That is to say, you can go on heating carbon until the hydrogen is driven off, and you then acquire more and more peculiar qualities in your carbon. Its resistance diminishes. Its density increases. It becomes gray in its color. Finally it reaches a hardness approaching the diamond; and it is not improbable that the diamond was produced by the elimination of the hydrogen from the carbon by intense heat. All other forms of carbon are amorphous. So much for the carbon filament. The carbon filament has to be maintained in close relation with the rest of the circuit, and various ways have been invented for that. Then as we proceed further from the incandescent conductor we come to those parts by which the lamp itself is attached to the main circuit by the holders, upon which a great deal of inventive ingenuity has been expended. As far as the glass globes are concerned there may be any variation of forms in their construction. They may be pear-shaped or globular. Glass lends itself to any shape, so that is not essential. But when we come to the vacuum we have something that we have to look at more particularly. A vacuum may be considered as representing so many foot pounds of energy expended. To produce a vacuum you have to lift a column of mercury and allow it to fall. It may be interesting to you to know something connected with the vacuum. I will entirely eliminate from view all the delicate instruments of Crookes, Gassiot, and others, because they are simply intended for scientific purposes, and we come to the discovery of Mr. Sprengel, which will enable you rapidly to make almost as perfect a vacuum as Mr. Crookes made.

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It consists of a simple fall tube of glass to the upper portion of which is connected the object to be exhausted and also the reservoir of mercury which is allowed to flow into this tube. Those are the elements. I have made vacua of one millionth of an atmosphere, and I think you ought not to stop much short of that in producing your vacuum for incandescent lamps. Imperfect vacua have this quality of conducting a wave of heat more readily; so that if you have an imperfect vacuum you will produce much less incandescing of the carbon conductor than you otherwise would. And if you go on adding air to your vacua you will find that with the same expenditure of foot pounds you have an enormous loss in light, and if you go still further (as Grove did more than twenty years ago) and fill your globe with other gases, you will find, if you take, for instance, hydrogen gas, that it is very difficult to produce any incandescence of the carbon at all, the hydrogen gas serving to conduct away the heat with the greatest rapidity. You cannot get your carbon into incandescence without an enormous increase of energy. Therefore, to return, in order to produce the most economical incandescence of carbon we must have our vacuum as perfect as possible. You are all familiar, I suppose, with the manufacture of charcoal. You take an organic substance, exclude it from the air and heat it. The volatile hydro-carbons pass off and as you apply your heat more and more you get the desired carbon. The same thing is carried on with much greater refinement in the manufacture of carbons for incandescent lamps, because you are dealing with things of great tenuity and fragility. They have to be carbonized in certain modes. The carbon I have in my hands shows how remarkable is the plasticity of carbon. I could write my name in carbon if I wished and then carbonize it, and I would get a diminution of the size of letters, but it would retain its form just as well as if I were writing it in a glass rod. Carbon when heated is plastic, perfectly plastic, and you may form it into knots, but when it is cold it becomes more fragile. It is, however, very elastic when cold. It is possible to insert into a globe a carbon curved into an incomplete circle of very much greater diameter than the orifice through which it was introduced. After all, incandescent lighting points to the use of very long conductors of carbon contained in large globes; so that it is very necessary, then, to put that carbon into such a shape as to diminish the cost of producing your vacua. Of course if you can put a greater length of carbon into the same compass, it becomes more economical to do so; but if, as has been invariably the case before, you have straight carbons you must correspondingly increase the length of your globe to such an extent, that I have really seen the matter carried to extremes. There is an enormous wast of energy in exhausting those globes. If you could have put that carbon into a much smaller area you could have diminished the vacuum considerably. I think you will admit that getting the carbons into economical areas is a very important point to be considered in the manufacture of incandescent lamps.

As to the attachments of lamps, they are various in their nature, and are matters of detail upon which I will not enter. In closing, gentlemen, I will again revert to the fact that I had no intention whatever of speaking on this subject, but only through the kindness of the president was I induced to do so. [Applause.]

ELECTRICAL DEVELOPMENT.

During the year 1885 the number of electrical companies organized in this country was 363. There will doubtless be a still larger increase during the current year. There were also issued 1,358 electrical patents during the same period. This field is already exhibiting signs of unusual activity, stimulated in a great measure by the comparative facility with which cases are acted upon in the patent office.

CORRESPONDENCE.

BOSTON.

Report of the Lamp Department.—Increase in Electric Street Lighting.—The Popular Demand for Illuminated Streets.—Additional Lamps Require Larger Appropriations.—Steadiness of Bell Telephone Stock.—Electric Legislation by the General Court.—Breaking of the Direct Cable.

The annual report of the lamp department is always an interesting document, and furnishes this year some valuable arguments in favor of electric lighting. The number of lamps of all kinds in use in the city on January 1, 1886, was as follows:

Gas	9,978
Oil	2,630
Electrics	446
Large gas lamps	63
Total	13,117

A total increase of 308 lamps.

The increase of the electric lamps is shown by the following figures:

January 1, 1883,	there were	114	electric lights.
" 1, 1884,	"	381	"
" 1, 1885,	"	401	"
" 1, 1886,	"	446	"

These lights are placed in different sections of the city, and are furnished by the following named companies:

Brush company, city proper	195	
" " Roxbury	43—	238
N. E. Weston company, city proper	55	
" South Boston	69	
" Charlestown	26—	150
Merchants', city proper	25	
Union, East Boston	33—	58
		446

The contracts with the Brush, New England Weston, and Merchants' Electric Lighting companies, expired on May 1, 1885. Previous to their expiration an earnest effort was made by the committee on lamps to secure a reduction in the price charged for electric lights, viz., 65 cents each per night, before entering into any new contracts; but in no instance did they meet with any success, as it was claimed by these companies that instead of a reduction, the city should pay more than the present price. The committee, therefore, not deeming it to be for the interests of the city to make new contracts under the terms proposed, these companies are now furnishing electric lights according to the terms of their old contracts, and under the provisions of the following order of the board of aldermen, dated April 27, 1885:

"*Ordered*, That the committee on lamps be authorized to arrange with the Brush Electric Lighting Co., N. E. Weston Electric Light Co., and the Merchants' Electric Light and Power Co., to furnish electric lights at the same price as named in their last contracts, until such time as a new contract may be made and approved by said committee."

There are no indications at present that any reduction from present prices will be offered during the present year, unless it should be deemed expedient to make contracts for a longer term than one year; but it may be possible to secure better terms than were proposed last year, and the matter of contracts for electric lights has therefore been left by the committee on lamps in such shape that it may be considered at any time hereafter, without detriment to the interests of the city.

It will be readily seen from the statement showing the number of electric lights now used by the city, that the matter of electric lighting has become an important feature in the business of this department. The number of them has steadily increased, and yet so urgent is the demand for them that, had not the work of this department been limited by the appropriation made for that purpose, the number would have been larger. The petitions for these lights are very numerous, and are always persistently pressed, and are not confined to any one locality or to one class of people; and so many places are pointed out where they are needed, and where they would really be very beneficial, that it is oftentimes very difficult to withstand the pressure which is made for them. All the petitioners unite upon one common ground—"that they are a protection to property and to those whose business or pleasure requires them to walk the streets after dark; that for the suppression of vice and prevention of crime they are almost as good as policemen;" and as many claim "that a city that is well lighted is well policed," an urgent demand is made for more light.

In compliance with many petitions, several lights have been placed in localities considered as resorts for people of questionable reputation, and, judging from reports made at this office, it would seem that much good has been accomplished. That more

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light is demanded by many people of this city is clearly shown by the experience of this department, and by the number of petitions now on file in this office, and it will be for the city council to determine what shall be the policy of this department during the present year.

The difference in cost of burning gas, oil and electric lights is as follows:

	1883.	1884.	1885.
Gas.........	$271,777.89	$255,463.30	$255,059.59
Oil.........	6,479.36	5,565.93	5,141.63
Electric....	58,855.18	90,785.80	99,523.28
	$337,112.43	$351,815.03	$359,724.50

The appropriation for the financial year ending on the 30th April, 1886, was.........................$500,000.00
Amount expended to Jan. 1st, 1886...... 351,125.79

Balance.........................$148,874.21

The price of gas for public lamps under existing contracts is from $1.30 to $2.00 per 1,000; while in 1877 it ranged from $2.00 to $2.90.

The number of men employed is 154, viz.: One superintendent, one clerk, two assistant clerks, 144 lighters, and six men in the repair shop.

The final issue of the Bell patent continues to excite more speculation away from Boston than at this telephonic centre. The stock has been steady, and while there is undoubtedly a grave concern as to the outcome, yet no one has lost his head over it as yet. A stock paying 17 per cent. on actual business in hard times is not seriously disturbed by rumors.

The legislature is grinding away at telephone and electric legislation, but has not yet reached the exciting period of public hearings. The New England telephone stockholders held their meeting in New York, as announced, and accepted the proposition of the American Bell Telephone Co.

The Western Union telegraph people in this city were notified on the evening of the 6th inst. of the breaking of the line of the Direct Cable company between Rye Beach and Torbay, N. S. Mr. Roche, the Western Union manager in this city, was asked for the use of a land wire from Rye overland to Nova Scotia, and promptly furnished it, so that the business of the cable company will go on without interruption. The cable has an advantage over the land wires in the fact that it is not affected by storms. The land wires last week, between the icicles and the wind, were pretty generally down, but they are at present in good working order. The break in the cable is supposed to be somewhere on the banks, and is probably caused, as usual, by the anchor of some fishing vessel catching in it. It may be a week or more before it is repaired Tests are already being made to determine where the break is, but the vessel of the cable company can only make the repairs in good weather, and a rough sea might postpone the work for some time.

BOSTON, February 17, 1886.

CHICAGO.

Troubles Caused by Swinging Arc Lamps.—An Improved Device for Suspending Them.—The Gray Telephone Company.—"No Connection with the Concern Across the Street."—A Chicago Syndicate to Control the Company's Affairs.

ONE of the most serious troubles with arc lighting, especially where the central plant system covers much territory and there are several outside lamps, is the difficulty of keeping clear of contacts which lead to ground. Awnings, iron frames, columns of metal, cornices, etc., are all more or less bugbears to the constructor in the commencement, as well as the parties operating the plant after installation.

Now, to arrange outside wires so as to protect these from such contacts, and their mischievous results, has been a matter of no little study among the members of the lighting fraternity, and sundry ingenious methods have resulted. The desiderata to be attained are:

Ease and certainty of raising and lowering the lamp for trimming and adjusting.

Positive rigidity of the lamp when drawn up, and certainty of its remaining in that position.

Doing away with slack wires, which contribute largely to the formation of grounds by contacts, and which are extremely untidy in appearance.

Some time since in these columns mention was made of a system which it was believed would accomplish all this. This plan has been adopted here, and hereafter will be used by the Chicago companies whenever a light for outside purposes is not permanently fixed in a given position.

The system spoken of consists of two rods in place of one. The upper—where these are placed one above the other—is firmly fixed to the wall of the building. At the outer extremity of this rod a pulley is placed through which the rope is run that governs the movements of the lower rod, which may be much longer than the upper or supporting rod, if desired.

Near the inner end of the supporting rod, at any desired point, the lower rod is attached to the upper by a hinge in such a manner that the outer end of this, when the rope is slackened, will swing downward and inward toward the building.

At a point near the outer end of the upper rod a simple latch engages with a lug on the lower rod, when this last is raised to its place, holding it positively in position. A second rope disengages this latch when the lamp is to be lowered.

Two or more cross arms of wood or metal are attached to the lower rod, and on these, insulators are placed, to which the wires leading to the lamp are fastened, and the lamp is suspended from the outer end of the rod. The advantages claimed are:

The untidy loop, which is objectionable on several accounts, is done away with.

The lamp cannot drop accidentally from a failure of the rope, as the strain is entirely taken off from it.

The lamp, when lowered, is at the least occupied portion of the walk—next the building—in the most accessible place for trimming.

The telephone war is quite a general topic of conversation—a quite natural sequence, when it is remembered that here is the home of Prof. Elisha Gray, who is one of the claimants of priority, and one, too, who certainly comes nearer than any of the hundred or less who have wanted, to be the original and only.

Mr. D. K. Tripp, Dr. Gray's attorney, has been interviewed several times since the new move in the telephone matter.

On a late occasion of this nature, Mr. Tripp was asked what he knew of the Pan-Electric Co,, and said:

"The only knowledge we have of the Pan-Electric Co. is what we have from the newspapers. If the Pan-Electric Co. possesses any telephonic instruments founded upon letters patent from the government, they must be simply for devices similar to the Overland and others who have heretofore attempted to do business, and are of no value except for mechanical purposes. I do not know anything of my own knowledge of the Pan-Electric Company, but I believe it is simply on paper, and its stock is valueless.

"The Bell company has no fears of any one in this contest except Gray. Its anxiety was apparent at the hearing in Washington, and the company knows as well as, if not better than, anyone else that when Gray's voice is heard the noise about the Pan-Electric and the political scandal will cease and the Bell people will sing another tune. It will not be Garland's character they will assail, but Gray's. It will not be the private correspondence of men in Congress they will publish, but they will attempt to destroy public confidence in the justice of Gray's case, resorting to like methods of publishing private and confidential correspondence between client and attorney, and thus attempt to weaken the charge of fraud which is so emphatically made. But we do not fear anything that may be said or done."

"* * * The Gray company is not yet fully organized. No officers have been elected, and no stock has been issued to Mr. Gray or any one else. Neither Mr. Garland nor any other public officer has any stock, nor any promise of any, and never will have unless they buy it and pay its market value. Not a share will be given away to any one, much less an officer of the government. Mr. Gray has had many offers of very large amounts of money to fight the Bell company, but none of them have yet been accepted. All the stock of the company will be held in one block by a board of trustees composed of well-known business men of this city until Mr. Gray's rights are settled by the United States supreme court. None will be on the market, and none will be sold, except to a small syndicate of Chicago's best business men, who will control all the business affairs of the country until all litigation is over.

"* * * Mr. Garland, I presume, never heard of Gray's case until after the filing of the government suit in Memphis, and possibly not until the hearing before Lamar. Gray's appearance before Lamar created a profound sensation, not only among the attorneys of the Bell company, but among the government officials, and as the discovery of Gray's rights was only known among a very few men, outside entirely of official circles, it was impossible for Garland to have any interest in the matter. * * * Mr. Garland did what any honest judge would do if called upon to act upon a question in which he had any interest—he retired from the case, and allowed it to be considered by others. Besides all this nonsense, the Pan-Electric has had nothing to do with the case. The Pan-Electric has never made an application for recognition, for it had no case, for from their own statements they had no patents to operate under. The National Improved Telephone Co. of New Orleans made the first application, and there is not a word of evidence showing that Garland had any interest in the latter company. Mr. Garland should be sustained by the administration, and doubtless will be."

"What did Bell claim in his application or 1876?"

"His application of Feb. 14, 1876 (which is claimed to be a speaking telephone), is described as an 'improvement in multiple telegraphy,' and there is not a word in it about transmitting

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articulate speech. In the fourth clause of his 1877 patent, issued eighteen months after, he describes and swears that his so-called speaking telephone of 1876 is an instrument capable of transmitting only a single note. It is clear that an instrument capable of transmitting only a single note is incapable of transmitting articulate speech. If you were to trace the history of the inventions described in the patent of '76, you would find that Bell's supposed invention was the mode of undulating a voltaic current by throwing a magneto current upon it, and thus you will see that his desire was to secure a monopoly in telegraphy by a combination of these two currents, and nothing more. * * * It has taken the combined efforts of the courts, experts and lawyers, with all the advantages of collusion, suppression, and fraud, to make a telephone out of the patent of March, 1876.

"Gray was not indefinite. He was clear, and knew just what he wanted. He says: 'My claim is for a speaking telephone. The obvious practical application of my improvement will be to enable persons at a distance to converse with each other through a telegraph circuit just as they do now in each other's presence, or through a speaking tube;' and the description of his method of, and apparatus for, accomplishing this is just as clear.

"I presume the government will bring suit to annul the Bell patent in a few days—at least so I am informed. If the suit results, as we believe it will, in the destruction of Bell's patent, we shall of course proceed to procure a patent for Gray covering all he may be entitled to. If he is entitled to anything, he is entitled to all, and if he has been deprived of his rights by collusion and fraud, as we verily believe, the people of this country are so just that they will rejoice in his success.

"The (Gray's) patent would date from its issuance, and would of course run for seventeen years. It is a grave question whether Gray would not have a suit against Bell. * * * It has been supposed that Gray has received large remuneration from this invention. This is not the case. Prof. Gray has never received a dollar for his invention of the telephone."

"If Gray gets a patent, what effect will it have on the Globe, and other telephone companies' stock?"

"The Globe company is founded on the Meucci claims, I understand, and some devices patented by others. The Meucci caveat covers the 'Lovers' Telegraph,' so called, and cannot be considered as an invention He has no legal standing, even if he had made such a description of a telephone as to enable one skilled in the art to reproduce it. It cannot be considered a prior publication, because it has not disclosed a telephone, and cannot, therefore, be of any material use in breaking down the Bell patent. Therefore, any stock of any telephone company can be of little value not founded on some solid grounds. However, we are willing, and even anxious, to let all have a fair show, and only desire to win if right. Prof. Gray wishes it understood that he stands or falls upon the absolute merits of his inventions, and will concede to his rivals all that they are entitled to."

CHICAGO, Feb. 16, 1886.

WASHINGTON.

The Amended Bill for Relief of Military Operators.—Government Telegraph Control Not Encouraged.—Extension of Signal Service Lines in the South.—An Effort to Curtail the Luxury of Passes and Franks.—Experimental Lighting at the Capitol.

VERY little has been done by congress during the present session of special interest to the electrical public, or any one else. The senate military committee has evolved a substitute for the sundry bills introduced for the relief of telegraph operators during the war. As the substitute has been practically adopted by the sub-committee of the house military committee, it will probably pass in that form if at all.

Early this month president Norvin Green was invited to appear before the house committee on post-offices and post-roads, to give his views on governmental control of the telegraph, but he plead a want of time to prepare his argument and collect his statistics, and the hearing was not had. The committee has subsequently put itself on record as against the construction at public expense of competing telegraph lines, but left the questions of leasing lines, or contracting for the transmission of despatches through the agency of postal officials, open, in order that parties favoring the schemes may be heard. There is but little cause to believe that any of the proposed plans will take any definite shape this session. There seems to be but little pressure for them outside or inside. The Pan telephone seems to have given a surcharge of electricity all around, and no one appears anxious to take hold

A small bill was reported in the house to day by Gen. Viele for a military signal service line from Sanford to Point Jupiter in Florida. This will extend communication about 150 miles further south, to the extreme southern section of the state. The estimated cost is $17,000. A similar bill is pending in committee for a couple of short lines from Georgetown, S. C., to South Island and to Waverly Mills, the two to cost $3,000.

Hon. John A. Anderson, of Kansas, who has been prominent in government telegraph schemes, has introduced a bill prohibiting the use of railroad and other passes, and of telegraph franks, by members of congress and the judiciary of the United States. The acceptance of a free pass or frank, or of a ticket, at a price under the usual rates, works a forfeiture of pay due, and the tender of a pass, ticket or frank, is punishable by a fine of $1,000—while the company so transporting or transmitting is to pay a fine of $1,000—for each director of said company. Of course no action will be had, and congressmen will come and go on their railroad passes, and affix their free stamps to their telegraphic despatches.

In the matter of lighting the capitol by electricity, no official action has been taken. Since December the Edison people have lighted portions of the senate wing at their own expense, and have made so good an impression that I shall be quite surprised if they do not get an order to light that end of the building next year. The Thomson-Houston people have made some effort to show their lights in the house end, but from a variety of causes it has not proved a success. The house wing will, I think, await the full test of the Edison system at the other end, and perhaps follow a year later if the experiment seems to justify it.

WASHINGTON, February 23, 1886.

PHILADELPHIA.

A Simple Method of Evading the Law.—An Underground Company Evincing Signs of Life.—No Progress in Burying Wires.—The City Authorities Refrain from Cutting Lines.

THE Pennsylvania Telephone Co. recently sought to file an amendment to its charter at the state department enabling it to cover additional territory. The attorney-general decided that such action was illegal. The corporation then secured a charter for the Pennsylvania and West Jersey Telephone Company, which proposed to take in the desired territory. Since then the company sold its interest to the Pennsylvania Telephone Company, which is now in the possession of all the privileges it endeavored to obtain by the amendment of its charter.

A meeting of the stockholders of the National Underground Electric Company of New Jersey, was held a few days ago in this city, Mr. G. Morgan Eldridge in the chair. Mr. W. H. R. Lukens, solicitor for the company, stated that the company was in a dormant condition, and that it had been the intention to file a bill in equity to recover what was claimed as an illegal sale by the former board of directors, who had sold to Mr. W. H. Kern 5,000 shares of the stock of the Philadelphia Underground Company. Mr. Kern had recently offered to convey to the National Company 50,000 shares (one-fourth of the capital stock) of the People's Underground Electric Company, of Pennsylvania.

Mr. Lukens offered the following resolution, which was unanimously adopted:

Resolved, That we, the stockholders of the National Underground Electric Company of New Jersey, confirm the action of the board of directors with reference to the compromise between this company and Mr. W. H. Kern, and the board of directors is hereby authorized, on receipt of 50,000 shares full paid, of the capital stock of the People's Underground Electric Company of Pennsylvania, to convey to the People's Company the property of the Philadelphia Underground Electric Company, together with the right for the State of Pennsylvania of all the patents held by the National Underground Electric Company of New Jersey.

There is a great deal of talk, pro and con, in reference to placing all wires underground, but that's about all it amounts to. The city authorities have *not yet* cut the wires, as they promised to do, and things remain in about the same condition as they did a year ago.

PHILADELPHIA, Feb. 21, 1886.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICIAN AND ELECTRICAL ENGINEER, 115 *Nassau Street, New York city.*

AN AMERICAN PUBLISHER'S EXPLANATION.

[49]—In the second edition of Prof. S. P. Thompson's work upon "Dynamo Electric Machinery," which has recently appeared, I notice that the author has reprinted the preface which appeared to his first edition. This original preface contained certain statements which at the time I passed over in silence, because I thought the majority of the readers of his book in this country would readily see the injustice of the reflections contained therein. My reasons for thinking so were, that inasmuch as the statements there made were evidently penned in an unfriendly spirit, and as they seemed to give an unjust impression regarding the dealing of American publishers with English authors, they were

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at the same time accompanied with a positive declaration that the lectures complained of as reprinted by me, were reprinted as well in the *Electrician* (English), the *English Mechanic*, and other technical journals, and were translated into French; and as Prof. Thompson did not intimate that he was the recipient of a check from these journals, or from the French publisher, I imagined that Prof. Thompson's readers, in this country at least, would not judge me harshly for not doing what no one else who had used his lectures had done, or which even he (Prof. Thompson) would seem to have expected them to do.

I think, perhaps, now that this second edition of his extended work has appeared, containing this original preface, that a statement of the case may properly be made.

In 1883 there appeared in the *Journal of the Society of Arts* a series of papers, being certain lectures delivered by Prof. Thompson. As is the custom of the editor of my magazine, when any really valuable contributions appear in that journal, he reprinted them, and they may be found in the *Engineering Magazine* for March, April and May, 1883, duly credited to the *Journal of the Society of Arts*. Subsequently they were printed in a collected form in my "Science Series," after having been submitted to the able editorship of Mr. F. L. Pope. In this form I printed 1,000 copies, and after paying the cost of the cuts, paper, printing and binding, when all are sold, at the small retail price of 50 cents, at which they were placed, there will be but a very inadequate margin of profit on the venture. The author seems to ignore the fact that the magazine in which his lectures appeared in this country, and which magazine is conducted at a considerable annual loss to the publisher, first gave publicity to them here, and which the subsequent reprinting of them in the "Science Series" helped to enhance, and to this fact, let me assure the author, is due very much of his reputation as well as of the demand for his larger work in the United States.

D. VAN NOSTRAND.

NEW YORK, January 10, 1886.

ELECTRICAL NEWS AND NOTES.

THE NATIONAL ELECTRIC LIGHT ASSOCIATION.

ANNUAL MEETING AT BALTIMORE, FEBRUARY 10-12, 1886.

THE first annual meeting of the association was called to order by president Morrison at the Carrollton Hotel, Baltimore, February 10, at 12 M. About seventy members and associates were in attendance. Mayor Hodges and other prominent citizens of Baltimore were present, while the sessions were daily visited by many gentlemen interested in electrical progress. President Morrison spoke as follows:

"*Gentlemen of the National Electric Light Association*—The success which has attended our association so far must be very gratifying. Its numbers, its popularity and its usefulness must also afford you a great deal of gratification. From a small group of men who gathered together at the Pacific Hotel, Chicago, one year ago, it has grown to an association numbering hundreds of members, and its influence has already been felt through all the ramifications of the electric lighting business. We meet as scientists and as practical men. The former indicate the course along which the practical man may walk and achieve such results as past history promises the future. Baltimore extends the hand of welcome to you, and I may say just now that all the electrical apparatus invented in this country has had its birth or to some extent its fruition, in this city. The telegraph, the telephone, the electric light, the electric locomotive, have to some extent first been made accomplished facts here. At our last meeting at the Hotel Dam, in New York, a distribution of the subjects presented to the convention was made to various committees, whose reports and the accompanying papers you will be called upon to consider. We have with us Maryland's representatives and the mayor of the city. The subjects to be discussed will include electricity as an illuminant, arc *vs.* incandescent lights, the placing of wires underground, operating expenses, and the relation of electric lighting to insurance. The names of Dr. Otto Moses, Prof. George Benjamin, Major Heap, of the United States navy; E. R, Weeks, of Kansas City; R. W. Pope and Geo. Worthington, of New York, and C. J. H. Woodbury, of Boston, are a sufficient guarantee of the intelligent manner in which their subjects are likely to be handled. Among those who have accepted invitations are professor Rowland, of the Johns Hopkins University, whose reputation in electric matters is not confined to his own country; ensign Louis Duncan, of the United States navy, chairman of the committee on the life tests of incandescent lamps and dynamos, instituted by the Franklin Institute of Philadelphia; Prof. Kimball and Dr. Perkins of the Johns Hopkins University. I have no doubt that during the session they will offer many valuable suggestions. I have the honor of introducing to you the Hon. James Hodges, mayor of the city of Baltimore, whose name has been for nearly half a century identified with everything that was beneficial to the city of Baltimore—one who not only encourages progress, but keeps along, step by step, by her side; one whose words of welcome come not merely from the lips, but which are the genuine expression of the heart, the great heart of the hospitable people of Baltimore."

With this introduction, Mr. Hodges rose and delivered an address, in which he said:

"As the mayor of Baltimore, I extend to the delegates of the National Electric Light Association a sincere and cordial welcome to this city. As it is one of geographical centrality, whose inhabitants are proverbially kind-hearted and hospitable, I deem it not egotistical to remark that the place of your meeting is well chosen. I am only repeating a platitude when I say that safety to life and property, and good living and good cheer are among the distinguishing characteristics of this community, and I underwrite this bond to you.

"The people of Baltimore cannot but feel a lively interest in the questions to be discussed in this convention. It was here, in 1844, that Morse first brought into successful operation his telegraphic line, connecting the cities of Baltimore and Washington. No grander result can ever be achieved by human genius over space and time. I witnessed its first operation at this end of the line in a brick building which stood on a small part of the ground now occupied by the City Hall, with a feeling of awe and wonderment from which I have never recovered. A few days afterwards I went to Washington with some friends on a visit, and was introduced to Prof. Morse in his office at the Capitol. He explained his ingenious invention to us with a display of enthusiasm which was as childlike as it was delightful. It was here, in 1848, that George B. Simpson exhibited the first successful submarine telegraph, the one now in practical use by all telegraph companies.

"It was here, in 1878, that the first practical test was made between the original Bell telephone and the Edison carbon transmitter, which resulted in favor of Edison, and brought about the consolidation of the two interests. Baltimore was the second city on the American continent, in 1881, to apply on a large scale the system of electric lighting to its public thoroughfares; and the first, in 1885, to equip and put into successful operation the electric railroad, which connects the village of Hampden with this city. Hence, as I have before intimated, the place of your meeting is most appropriately chosen. You have assembled here to develop and promote a science of great utility to the world; and which, in my judgment, is only in the infancy of its application to the necessities and comforts of mankind. As a means of protecting life and property, the system of electric lighting is only second in efficiency to the honest and efficacious police. Men are deterred from committing crimes under the glare of electric lights, though seemingly alone, for fear that some one from a distance, screened from view, may be looking on. An electric light is a nocturnal joy to an honest man, but a scarecrow to a thief.

"I will not venture to be instructive to this intelligent body of scientists, at whose feet I might sit to study the principles and appliances of electricity, but I will ask your indulgence so far as to say what, doubtless, you already know, that recently the electric light has been utilized as a means to aid medical and surgical diagnosis, and to assist, by its internal application, to illuminate the various dark cavities of the human form, which surgeons and physicians have had no previous means of exploring. This has been accomplished by the invention and application of an ingenious little electric light supplied from a small portable battery. But I will not talk to you any longer about a matter which you understand much better than I do. I will simply renew my best wishes for the success of your convention, and for the best possible mixture of social and intellectual enjoyment for yourselves while sojourning in our city.

"I would be pleased to see you all at the City Hall before you take your departure from Baltimore."

READY FOR BUSINESS

The formalities of opening being thus pleasantly disposed of, the real work of the meeting was entered upon by the reading of a paper upon the "Proper Construction and Maintenance of Circuits," by E. R. Weeks, of Kansas City. See page 90.

Mr. Cooper, of Brooklyn, referring to the recommendation in the report to place poles 100 feet apart thought it would be too much like a picket fence.

Mr. Weeks, in reply, referred to the fact that the insulation is very easily cut at the tie-wire. In order to prevent that, as large a tie-wire and as large an insulator as possible were used, so as to have a large bearing for the line, and above all have the supports as near together as possible. Of course, in some cases it is absolutely necessary to have the poles less frequent. In cases where it is not practicable to construct in any other way, he would have long spans, but he considers it advisable in most cases to shorten the span.

Mr. King, of Minneapolis, said in his city they were running some 225 lights, suspended over the centre of the street at the intersections by means of a sheave pulley and winding drum. This system had been in operation a year. "We have," the speaker continued, "a great many zephyrs in the air there at this season of the year, sometimes snow, and the thermometer gets down into the basement. We have never experienced any trouble there. Our lamps work very satisfactorily, indeed. We consider it very much the cheaper and preferable way, and are very much pleased with the system."

Mr. Cooper—In what way is it cheaper?

Mr. King—It is cheaper and more effective. The apparatus which we use is the invention of a Minneapolis man. It costs us something like six dollars.

Mr. Cooper—The cheapness is in the construction?

Mr. King—So far as attendance is concerned, we have had no expense from that whatever. We hang our lamps so that with our apparatus the lamps can be lowered within twelve feet of the street. We can bring them down to the sidewalk if we wish to. A carriage can pass by the lamp without striking it. It also furnishes facilities for adjusting the lamp while the current is on. We have trimmers who take a 10-foot step-ladder and travel probably six miles, and clean 40 to 50 lamps in a day.

Mr. Cooper—Then that is about half as much as they generally trim, isn't it?

Mr. King—Of course they can trim many more lamps, say in a store.

Mr. Cooper—On a stationary pole they trim more than that. We have trimmed 75 to 90 lamps on stationary poles. Therefore ours is cheaper.

Mr. King—I wish you would tell me where I can hire one of those fellows. We set two poles, run a telegraph wire across from pole to pole, and put a double sheave pulley on that wire. The upper sheave runs on this supporting wire and the cable which suspends the lamp runs through the lower one, and back to the winding wire.

Mr. Linnell, of Hartford, said that, in the east especially, city authorities objected to wires running across the streets on account of their interference with processions, etc.

Mr. Ridlon, of Boston, thought that the liability to accident was the greatest objection to stringing lamps diagonally across the street. He had known many cases where the moving of a lamp backward and forward had so worn the wire that it broke and allowed the lamp to fall.

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Mr. King said that in the system he had described they had a double support. The upper wire, which carries the sheaves and pulley, is the first. In addition to that they have a ¼-inch wire rope, so that if the upper wire should break there would be no danger. He would not hesitate to run a 500-pound weight on that galvanized wire and swing it there.

Mr. Cooper said that his company had two poles with tackle like that described by Mr. King, and it broke and resulted in injuries to persons which cost the company $1,500. He thought the Brady mast-arm a good thing.

Mr. Morrison—With the construction carefully attended to, there ought to be no danger whatever from the plan suggested. The objection has been recognized, wherever that plan is adopted, that you have a number of unsightly wires across the street.

Mr. Cooper—I have had experience with both plans, and I found one stationary and the other not.

Mr. Weeks—I have had experience with both. The cost of construction is less with the lamp on the top of the pole, or by the use of the Brady mast-arm set out of the street. The cost of maintenance has been shown to be less. So that, if we have a more economical construction and more economical maintenance with that system, it seems to me that others must fall to the ground. Occasionally it is necessary to move a house. If that is done you have got to take all your tackle down. I know a case where a man got a little out with the light companies and hauled a 75-foot derrick up and down the street, and kept them moving their wires up and down the street hither and thither.

Mr. Cooper referred to another objection, which was that in putting out the lamps, a great many times the carbons were slid by.

Mr. King—We have not had that trouble, and we do not have a man with a derrick and a brass band parading our streets. Occasionally we have a house moved; though, as a rule, our people are well pleased when they get located and stay right in the one spot. As to the first cost, the cost to us is that of the drum and sheave and wire rope, and the piece of telegraph wire and one pole, and it is not expensive up in our country. It is very cheap.

Mr. Weeks mentioned the liability to variable contacts as another objection to the system. It is almost impossible to keep your leading wires to the circuit tight in your binding posts.

Mr. King—We have not met with that trouble in our experience.

Mr. Weeks—I think you have; I saw your lights.

Mr. King—What time of night? (Laughter.)

The secretary then submitted his report.

The treasurer's report being called for, Mr. Cooper stated that the amount of cash on hand was $862.48, and that he had vouchers for all payments.

A paper on "Electricity as an Illuminant," was then read by Dr. Otto A. Moses. See page 89.

The convention then adjourned till 4 P. M.

AFTERNOON SESSION, WEDNESDAY, FEBRUARY 10TH.

After the convention was called to order at 4 o'clock, the roll was called.

The secretary read telegrams expressing the regret of the members at their inability to be present, and their wishes for the success of the convention, from George S. Bowen, of St. Louis; the Fort Wayne Jenney Electric Light Company, and E. A. Sperry.

A paper by Mr. John W. Beane, on the "History and Progress of Electric Lighting," was read by R. W. Ryan.

After a recess of ten minutes, a paper was read by Mr. T. C. Martin, of New York, on the "History and Progress of Electricity as Applied to Motors."

The following resolution, proposed by Mr. Duncan, was adopted:

Resolved, That the associate members are entitled to all the privileges of the floor, except the right to vote.

Mr. H. W. Pope proposed the following resolution:

Resolved, That a committee be appointed by the chair to tabulate rates for lights existing in the various companies represented in this convention, and that said committee report at the next session of the convention.

The word "public" was inserted in the resolution on the suggestion of Mr. Duncan, and it was then adopted.

The president appointed on the committee Mr. H. W. Pope, Mr. Duncan, of Pittsburg, and Mr. J. F. Noonan, of Paterson, N. J.

Dr. Moses, referring to the subject of the paper read by Mr. Martin, said that the method of distributing electricity from central points, such as the coal fields, can be accomplished by low-tension machines. If, for instance, you burn your coal in the mine and simply transmit it to the surface to be stored, you can, by a proper arrangement of a series of battery systems, get your currents of any potential you please. You then will be able to insulate your line wire very properly. You can receive that safely at some city central station, there undergo a transformation into currents of low potential and distribute it then at the householder's door. That would probably be the way in which we should use electricity manufactured directly at the source of the fuel.

Mr. Upton read a paper on "Transmission of Power by Electricity." See page 96.

In reply to a question of Mr. Weeks, Mr. Upton stated that he thought it practicable to run an engine and dynamo all the time. But it was preferable to have a spare engine. There are several stations in New England running both arc and incandescent. He continued: "I think there is more money in selling power at $150 per horse-power than any electric light company is making selling light. In the New York Stock Exchange there is a motor of three-horse power that is running 300 tickers, and they are obtaining for that about $400 a horse-power a year."

Mr. De Camp—I cannot see the difference between the arc and the incandescent in regard to supplying power unless we duplicate our plant. The light, whether it be one or the other, may be said to commence at four o'clock. Now, we would either have to get our customers to dispense with the use of the motors at four o'clock or *vice versa*, or else double our plant. We are running about 200 small motors, used almost entirely for running sewing machines We charge for those motors a dollar a month. We will not make a contract for a less amount than five dollars. If a party puts in four motors, we will run those motors for five dollars a month. If he goes on and adds to those, we will charge him one dollar a month for every additional motor he puts in. They are supposed to be about one-twentieth of a horse-power. We run them on arc circuits with arc lights.

Mr. Upton—I rode yesterday on four or five different elevators running a mile away from the station. The motor was in the upper story locked up. These were freight elevators, but they told me it was just as easy to run passenger elevators in the same way. They ran with perfect ease. You have not begun to develop your business. That is my idea. I was talking to some people who are using the Daft system in Boston, who are paying $150 per horse-power. I think any of them would pay $300 a horse-power rather than not use them. My only experience has been where low-tension dynamos are used. I should suppose high-tension could be used with resistance boxes, or something of the sort.

Mr. H. W. Pope—With the Diehl motor there is no resistance. The field magnet is adjusted. It works very successfully. I tested it myself and derived a great deal of satisfaction from it. I worked it on a high tension wire.

Dr. Moses—Electrical power has not been used to any extent in the Edison district, although they originally forecasted it. It is, to a certain extent, a manufacturing district, particularly north of Fulton street.

After some further discussion, the meeting adjourned to 10 A.M. Thursday.

MORNING SESSION, THURSDAY, FEBRUARY 11TH.

The morning session on Thursday was devoted chiefly to the consideration of steam power as applied to electric lighting, and the discussion was opened by Mr. Frederick Fosdick, of Fitchburg, who addressed the meeting upon the subject. His argument was strongly in favor of what are known as low speed, in contradistinction to the high speed engines which are as persistently advocated by their adherents. It appeared from the remarks of Mr. Fosdick, and Messrs. Upton, De Camp, Evans, Morrison, Kerr, Cooper, Lynch, Weeks and Sims, who followed him, that the choice between the two systems depended upon the size of the plant operated. All classes of engines have, however, been considerably improved in order to meet the exacting demands of the electric lighting service. Condensing engines are found most economical where the water supply is free, but the water tax is so high in many cities that they are expensive in such locations.

Mr. H. W. Pope: I shall probably be called away this afternoon, and there are some few matters here I have been requested to introduce. I move as an amendment to Article 3 of the constitution of this association the following: Strike out all after the words "executive committee," and add "shall be entitled to all the privileges of the association, but shall not be eligible to office or entitled to vote, and such associate members may be appointed to serve upon committees in the judgment of the executive committee." Adopted.

Mr. H. W. Pope—The Telephone Association, of which I have been a member for a number of years, at their convention in 1884 formed a very intelligent and competent committee to take up the subject of wire gauges. This committee, of which Mr. Sargent, of Brooklyn, was chairman, made a report, and this report recommended that the English standard gauge, which was regulated in England by an act of parliament to take effect by the 1st of March, 1884, be adopted by that association. They have sent a communication to this convention addressed to the president, to the effect that this gauge has been approved by the National Telephone Exchange Association, and requesting the co-operation of this association, with a view to the establishment of a uniform

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standard. Now, Mr. President, I offer the following resolution:

Resolved, That the new English board of trade standard wire gauge adopted by the National Telephone Exchange Association, September 9th, 1885, be and the same hereby is adopted as the official gauge of this association.

Resolved, That the president take such steps as in his judgment may seem necessary through a conference with the telephone association or other associations interested toward inducing Congress to legalize the same in the enforcement of contracts.

Resolved, That 1,000 copies of said standard gauge be printed for distribution by this association.

The resolution was seconded by Mr. Cooper.

Mr. H. W. Pope—It is hardly necessary to discuss this matter. It is a subject with which we are all pretty familiar. There are any quantity of gauges, and almost everybody knows the difficulty experienced not only in the electric light business, but in the telephone business, and it is very essential that this association do what it can to adopt a uniform gauge, and therefore I hope that this resolution will prevail.

Mr. Ralph W. Pope—I would like to inquire about the larger sizes of the gauge—whether it runs uniformly up, so that the larger sized wires used by electric light companies will also be uniform?

Mr. H. W. Pope—The largest size they have here is No. 0000.

Mr. De Camp—That I think a very important thing, because the confusion of sizes of wire is a very great annoyance.

Mr. Cooper—As an amendment to that resolution, I would move that the chair appoint a committee of three with authority to act in the interests of the Electric Light Association, and report such action at the next session. Adopted.

The President—The question now occurs on the original resolution as amended. The original resolution as amended was adopted.

The chair appointed Mr. Charles Cooper, Mr. Ralph W. Pope and Dr. Otto A. Moses as the committee.

Mr. H. W. Pope—I was appointed chairman of a committee yesterday on the matter of electric light rates. After a discussion of the subject we decided that in view of the fact that we could not get any record that could be put in the minutes of this meeting, that it was not necessary to report, if the association would give this, or some other committee, power to act after the meeting of this convention. The intention is to get as nearly a correct list of rates and general statistical information of the various electric light companies as possible.

Mr. Weeks—I move you that the committee be made a standing committee and report at our next convention, six months hence. Agreed to.

Mr. De Camp—I have a paper in my hand that was adopted by the Philadelphia company in making their reports showing the cost of their operations on these particular items. I think that we can get a very great deal of valuable information if every company would adopt the same form or some other form. That would entail a great deal of labor, which I would be perfectly willing to devote to the subject if I felt that I would be supported by the members of this association—if there is a feeling on the part of the members of the association that they will co-operate in this thing. If we cannot have the co-operation of the majority of the members, I do not propose to undertake it.

The secretary—The president appoints the following committee on transportation:

For the *East*—J. F. Noonan, Paterson, N. J.; Henry D. Stanley, Bridgeport, Conn.; James English, New Haven, Conn.

For the *South*—L. M. Fishback, St. Louis, Mo.; Mr. Yarborough, Nashville, Tenn.

For the *West*—George H. Wadsworth, S. A. Duncan, Pittsburg, Pa.

Mr. R. W. Pope then submitted communications from the following gentlemen accepting honorary membership in the association: W. H. Preece, Prof. S. P. Thompson, R. E. Crompton, Dr. J. Hopkinson, and Prof. George Forbes, London; Joseph Wilson Swan, Lawnston, Eng.; John T. Sprague, Birmingham, and Edward Hospitalier and Z. T. Gramme, Paris; Dr. Werner Siemens, Berlin.

The convention then adjourned until 4 P. M.

AFTERNOON SESSION, THURSDAY, FEBRUARY 11TH.

The convention was called to order at 4 P. M., Mr. H. M. Cleveland, vice-president, in the chair.

Mr. Cooper—I have a resolution from the committee on standard gauge:

Resolved, That the new standard English gauge as officially adopted by the National Telephone Exchange Association, be and is hereby approved by the National Electric Light Association for the purpose of insuring uniformity in the mutual understanding of orders between manufacturers, dealers and consumers of wires for electrical purposes.

Resolved, That the associate members of this association engaged in the manufacture and sale of wires be requested to incorporate in their catalogues and price lists the stipulation that the standard gauge approved by the above associations be understood as applying to all orders, unless otherwise specified either in quoting prices or shipments.

Adopted.

Mr. H. W. Pope—I wish to offer the following resolution:

Resolved, That this committee or its successor be empowered and requested to confer with other associations similarly interested, with a view to the legalizing by Congress of such standard gauge for guidance in the preparation and enforcement of contracts.

Adopted.

The Chairman—The chair will appoint as a nominating committee Mr. De Camp, of Philadelphia; Mr. Gilbert, of New Haven, and Mr. King, of Minneapolis.

A paper on underground wires was then read by Mr. Ralph W. Pope. See page 93.

Mr. Pope—I have no information as to the reliable working of these different systems, as my investigations were conducted in such a way that it was hardly possible to get much satisfaction as to that. To determine on the general character of the work, it occurred to me that there might be gentlemen present in this convention who are familiar with some of the systems and who might be familiar with some of the troubles that were encountered, and therefore I have not gone into the question of their reliability, because I knew nothing about it. I simply stated the facts as I found them. The drawing which I referred to accompanies this paper, and is open for inspection. Drawing exhibited.

Dr. Moses—I listened to the paper of Mr. Pope with much surprise, because the convention cannot begin to conceive the labor he took in gathering the facts upon which he based his generalizations. I happen to be in a position myself to know of his assiduity in following up this question, and when he says there are 100 different plans, that means that he has investigated 100 different plans—very different indeed from reading the statement. It required his attention for many days, under great inconvenience occasionally, in order to gather that knowledge which was epitomized in that way. The subject is one that is new, and of course every one that had anything to say on it presented plans before the underground commission in New York, that being the point most prominent for the inventor. The underground commission examined all these things, and it is really surprising what ingenuity has been expended upon them. Looking upon it philosophically, before the actual demand for underground systems arises, we find there pretty much all the necessary material on hand. There are some companies, however, who have had the courage to put this thing into actual practice; notably the Philadelphia company, of which he spoke, and the one in Chicago, the Dorsett company, I believe. It may be interesting to the convention to know that the problem is a very difficult one. There is steam heating to be overcome; there are gas-pipes that thread their ways most tortuously under every street. Subterranean New York is getting to be something like subterranean Rome. There are layers of gas pipes; those that have been cut off and neglected, and those that have been twisted away by some other companies who found them in the way—altogether there is a perfect network combined with the sewer system, water system and others, that it makes it a very difficult problem to handle in New York. Any system, however, that is to be adopted there must be one of a combined character, though not necessarily a system that can be carried out in its entirety in every street. However, there are some systems that could be very largely introduced. Then again, in other places, it would be necessary to combine. The problem, if solved for New York—and this is promised very soon—will, I think, very much enlighten those who wish to put down an underground system elsewhere, because this combination system, if it is introduced there, will give all the necessary information, and I think that members of the convention who have that at heart can possess their souls in patience in the meantime, leaving very well alone.

Mr. De Camp—We have made a good many experiments, but we have not met with high success. We have recently had trials of three cables, all put in operation since the middle of November. One of them came to the inevitable about two weeks ago. The other two held out and were in operation when I left. One of them, however, had been running about three weeks when it was taken out and corrected and put down, and it has been running up to the present time apparently all right. I have a despatch from our superintendent, just received, which says: "The two cables have both given out."

A member—What kind of wires were they?

Mr. De Camp—I think they were regular line wires.

Mr. King—Not laid in a conduit?

Mr. De Camp—No, not in a conduit. We have not been at all encouraged with any experiment that we have made. One of these—I will not mention the name, because I do not think it is a proper thing to do, and it may be fixed up and we may make a success of it, for aught I know—one of them we hardly expected to succeed. It was one of those things that did not commend itself to us from the start, and the person who had the idea in his head acknowledged that he did not know anything at all about it. He had been told that certain material he had in there was a good insulator. We said go ahead and do it, and it turned out as we thought it would. The other was presented by a man, as I understand, of considerable knowledge in that direction, and for that reason we had a right to expect some success from him.

Mr. King—I would like to ask Mr. De Camp what he knows of the running of lights on wires through a conduit?

Mr. De Camp—I do not see how and where a conduit is going to very materially aid us until we get a wire to go through that

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conduit with insulation of itself irrespective of the conduit, impervious to all the influences which it may be subjected to underground. I think we have first got to find that, and when we have found that, to get to work and adopt a conduit or some convenient method of putting those wires underground. Another thing: We run down a line of street 60 feet wide. Suppose you can put that conduit in the centre of the street. When I say a 60 foot street, I mean the Philadelphia street, which is 60 feet from curb to curb; then you have 12 feet on each side. Then you have 42 feet from your conduit to your house, if you have the conduit in the centre of the street. Then we have got to have something of an insulator on our wire that will stand underground. We could not afford to build miniature conduits from the conduit proper to the house. If we did, the mileage of our miniature conduits, as I call them, would exceed our main conduits by a great deal; so that must be taken into the calculation. Now, the method used in Philadelphia, I think, is generally to put an ordinary gas pipe around the wire. Now, if the gas pipe has anything to do with it, why not dispense with the expensive iron conduit—because they are in sections and broken up—by the ordinary gas pipes? I think that that decides that there is no particular merit in that particular conduit so far as helping the insulation of the wires is concerned. In many cases they have simply taken the wire which was in the main already; one of them was an insulated wire, covered with a lead casing. I do not see why that would not answer just the same purpose as a pipe. But I cannot see anything in the conduit. When you discover something that is absolutely reliable as an insulator, you may be required to adopt some entirely different form of conduit from what has ever been devised.

In Philadelphia, I think, the top of the conduit is probably at an average of about 15 to 18 inches. We have a board of super visors in Philadelphia, appointed last year. It has passed a resolution that no conduit shall be laid less than two feet below the surface. In Chestnut street, for about two-thirds of the way from Broad street down, there is not room, if I am properly informed by the survey department, to lay a six-inch pipe. There are two lines of water pipe, two lines of gas pipe, a sewer and the present conduits there. There may be something else; I don't know. That is the case in a great many streets. Take a street like Park street, which is very broad. There may be room there. We have a peculiar city government; it is the only one the Lord ever made; they have a peculiar way of taxing the people there; we have gas works which belong to the city. I understand there is only one other city in the country that owns its own gas works. The gas company now have agreed to furnish the city with light for nothing, but when they were charging for it they charged at the rate of $15 per lamp post, assuming it to be a five-foot burner, and in the same report of the gas trustees they put down the cost of each city lamp based at $28.50. Now the city owns those, and they claim it is a great thing, but the result is that the private consumer has to pay enough to make up that difference. The city of Philadelphia has passed, I suppose, six or eight ordinances on the question of underground wires, and when the original ordinance was passed fixing the time for putting the wires underground, there was an amendment incorporated in it that the ordinance should not provide for city wires. Some one asked, why so? "Why, the city hasn't money enough," was the reply. They had a large mileage of wires, but the outlying wires were not in the section. So far as their main lines were concerned, there is no reason why they should not bury them. They have always exempted themselves from the different ordinances that were passed.

Mr. Hotchkiss—I do not think there is a doubt in the minds of the gentlemen present but what wires can be placed underground and made to work successfully, provided a proper quantity and quality of material is used. Whether the investment will be remunerative cannot be regulated by some town in the state of Wisconsin in comparison with the city of New York or the city of Baltimore.

Mr. King—In our locality just now it seems to me that there are various objections to a conduit system of any kind. A conduit must of course be rigid, and any disturbance of the soil either by force or by the breakage of water pipes would endanger it of course; and in our climate especially, where the frost during the winter prevails down toward that point which the Universalists don't believe in, it would be a very expensive thing to lay a conduit. Our frost gets down eight or nine feet sometimes, and I agree with Mr. De Camp that if we go underground at all, the conduit seems to be a useless thing. I think we ought to stay on top of the earth for a while longer.

Mr. Callender—I begin to think that Mr. De Camp is somewhat in the position of the evil spirit of underground wires. In every experiment that Mr. De Camp has told of that has been undertaken in Philadelphia, the result, he informs us, was in every case a lamentable failure. I do not think it is quite creditable to engineers or electric light people and those interested in the subject, that the statement go forth from this association that gentlemen here have experimented with underground wires and find it quite impossible to run their arc currents underground. These are the facts that a man would gather from listening to Mr. De Camp to-day and at our last meeting in New York. I do not think that any of you who have given any careful consideration to the matter of what is necessary for underground wires, as Mr. Pope evidently has done from the very careful paper he read to-day, but must come to the conclusion that two things are necessary before you can get an underground circuit to work satisfactorily. It is not sufficient to get an insulated wire and bury it in the earth. An insulated wire will not turn a pick or other instrument with which it may be struck, nor can it by any possibility resist the action of stones or sand or any similar material that will be found in the earth. You have got to provide yourself with a conduit and with an insulated wire. An individual piece of underground work has got to be looked upon as a special piece of engineering, and difficulties occur in this special piece of work that have to be specially overcome It is no use for any man to come to you and say this is the only way to put wires underground. This is absurd. Take a territory in which wires have been put underground. In the putting of those wires underground certain principles have been evolved. You have to adopt these principles to work which you have to do. Mr. De Camp desires to put his wires underground. There is no difficulty at all in his doing so. There are several manufacturing concerns who are reputable, who stand ready to make their word good and to do underground electric lighting and to do it satisfactorily. We completed a plant in Washington in November for arc lighting. It was for the United States company for their new station near the capitol. All the wires that come from the station go from one spot overhead to a pole, and from there the whole of the wires go underground. Most of them go two-thirds of the way up Pennsylvania avenue, and some of them go up through the capitol grounds to the capitol. There are in the neighborhood of 20 miles of arc wire that have been working underground, both in the United States and Thomson-Houston systems. Tests have been taken of those cables recently, and they are perfectly satisfactory. There can be no deterioration in a system that is thoroughly well worked out and thoroughly well laid. I do not wish it to go from the association that the underground wire question is one of which you are afraid, of which you cannot see any successful ending, and of which you are afraid financially. The calculations that have been gone into by those companies who have gone underground on any reasonable scale, show that it is economy to do so. I refer you to an article that appeared last week in the *Electrical Review*, I think it was, describing Mr. Hapgood's experience in Detroit. Even there he finds it is economy to use his wires underground in the Dorsett conduit, as against overhead.

Mr. De Camp—I do not wish to be personal, but the circumstances are such that probably it may be so considered. When you referred to this matter, I think I understood what you meant—that the cable you put down for the Brush Electric Light Co. was injured through neglect on our part, or some misjudgment in laying the cable. The very fact of the cable breaking, or a leak coming there, has destroyed any possible evidence of the cause of it. Any man who has ever connected light wires knows what that is. Every man who has gone there and made experiments has had proper attention paid to him. Every facility has been offered to him honestly and in good faith. Save one exception—omitting these two which I have not heard from—in every instance our co-operation had been abused. We have been abused by all except one man who, when he failed, closed his mouth and went away, and he acknowledged his failure. Now we have made those experiments for, I suppose, 15 people. We do not decline to do it yet; but we have not met with the courtesy from the people to whom we have afforded these facilities, that we have extended to them.

Mr. Morrison—It would be a pity to let these questions pass without saying something further. No electrical engineer would dare to stand on this floor and say that it was an impossible thing to place the electric lighting wires underground, and have them successfully operated underground. It is possible and it is feasible. The enormous cost of such an operation, however, stands as a bar to the work, while the men would be called upon to invest their money and look upon it as an experimental operation, experimental in this country to a certain extent. The fact that electric lighting wires and all other classes of wires are being operated underground, and successfully operated, settles that question. In the city of Washington, where they will not permit the putting up of any new lines overhead, and where our people are compelled to put their wires underground, they are operated with success. In Europe most of the wires of the large cities, in one shape or another, are operated underground, or in conduits that are provided for wires and for other purposes at the same time. The history of these underground matters on the other side of the water is the history of the telegraph and of electric matters generally. It is not worth my while to go into it. It has been all talked over so that the question has about settled itself. Our case—I now speak from the electric lighting standpoint—is about this: In the city of New York the most searching investigation is being made in this direction, not for the purpose of settling the question as to the possibility of placing wires underground, but as to adopting the

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best method already provided for that purpose. We take it that it would be unfair to the men who have put their money into this business, and who have plants of overhead wires, to compel them to adopt any system until some plan has passed under this rod in New York, and this question has been to some extent settled, not only by the ordering of the wires underground, not only by providing a means of placing the wires underground, but by giving us the right to wait a reasonable time after such system has been adopted by the New York subway commission to allow us to see whether it is a success or not. I would like to treat every system fairly. I have tested under my own hand two plans for underground wires; one was a system of placing a bare wire in a bed of bitumen, Rittenhouse's plan, it was called. He had a lot of buttons strung on a wire, and put the wire and buttons in the asphalt. I told him the buttons were of no account, but he put cubes of terra-cotta on the wire and buried the wire in the bitumen. Now, that did not exactly receive fair play. As I passed through the prison yard, where the experiments were being made, and out again on Van Buren street, a distance of about three-quarters of a mile, I saw in going along that the workmen were dropping the sand in as the bitumen was being poured in. The line operated for about two or three months, and then it began to show faults, and grew worse until we had to abandon it. The other experiment was made in the same neighborhood by me with a cable covered with kerite. The wire was buried underground, and carefully watched day by day by myself and Mr. Orford, and it showed little or no signs of deterioration. We kept it underground, kept it in actual service, working it in a current along with about 40 or 50 miles of No. 4 overhead wires. We coupled our circuit up. All our overhead wires were made up of No. 4 Brown and Sharpe's gauge.

At one time you have a circuit with 60 lights, and in three or four minutes you have no more than 20 lights on it. Take, say, three, four, five, six, seven, eight, nine circuits and loop them together one after another, and in that way we work frequently through 40, 50, and even 80 miles of wire. This was a stranded cable with about, if I recollect rightly now, 8-32 of kerite insulation on it. We were working through this cable all this time, and through the varying distances of wire coupled up in these circuits, and we operated from 20 lights to 60 lights over that mileage of 40, 50 or 60 miles circuit, including this cable. We had no difficulty from the cable, and only removed it when we had to use the locality for some other purpose. It was in the service, I judge, for some eight or ten months without showing any signs of deterioration. These are the only two experiments that I have seen made.

We do not want to place our wires underground at all, to begin with. In the second place, we insist on fair play on the part of legislators; that they will keep their hands from us until something has been reached by those who are engaged in solving this problem—I now refer to this same subway commission—until they have gone before the world with some settlement of this difficulty from their standpoint. After they have done this, and the plan is adopted, then give us a reasonable time to see whether that plan is a proper one. Then after that, it is perfectly proper for the authorities to come along and say, there is a plan; go on and use it. When the time comes, I do not think you will find any opposition from any electric lighting man from that point. There is less difficulty from our side of the house than from the telegraph people, because the placing of an electric lighting wire underground is very little more expensive than building it overhead. We do not want to avoid the underground business particularly. All we want is for them to say to us, here is a system properly devised and tested, and here are the results.

Now, the Callender Insulating Company have got work in Washington, and up to the present time, I have it by authority from the superintendent of the police and fire telegraph of Baltimore, that it is giving good satisfaction. The wires are being placed underground in conduits, and they report good satisfaction. You cannot make a telegraph pole or an electric light pole an ornament, they are more or less a nuisance on the streets, and so those interested in the appearance of the city would like to get rid of these wires. The mayor has used pretty strong language in the matter of underground wires. He says: "There is no two opinions in this community concerning the necessity and expediency of an early abolishment of the overhead city wires now in use, the expansion of which has become so great as to be justly and generally regarded as an intolerable nuisance, while the wires themselves are terrible to the imagination as suggesting an increased loss of property and life in case of fire. The poles are an encumbrance on the sidewalk. They form a mass of unsightliness," etc.

He expresses there about the sentiment of it. You have there quotations from Mr. McAlees, who is present in the room now, giving the result of his observations in the different cities where the underground system is used. Upon that, legislation will be asked in this city looking to experimental work, probably, so that in the coming year you will doubtless have the result of a good many practical experiments laid before this association. Sometimes you find the chief engineer of the fire department making a report about the danger to the men in his department from the electric lighting wires; but none of these are true. I never knew a fireman to be killed by shock from an electric light wire. I never knew one to be injured in that way. You see extraordinary stories printed in the newspapers once in a while about this, that, and the other thing, and the chief engineer of the Baltimore fire department is no exception to that general rule. He puts himself on record in a report (which will be preserved in the archives of the city) as saying that numbers of lives have been lost through the agency of overhead wires. For those of you who have not the honor of an acquaintance with this gentleman, I beg to say that this is about on a line with the general statements he makes with regard to every matter, public and private. I do not know whether he would have sense enough to tell the truth if he knew how. But when you take a city official in as high a position as that, and permit him to display such malicious ignorance as he has displayed in the quotation I have given, it is time to infuse a little more brains and less muscle into the government of the fire department. I have got to leave this underground question with these few remarks. I think fair play would indicate a waiting policy on the part of the state and municipal governments, until the time has arrived when some solution of this question has been made by those engaged in endeavoring to solve it. I think that we should treat the case with grave consideration, and should endeavor to treat every man who is engaged in this line of business with absolute fairness, because the man who really solves this problem, Mr. President, the man who brings before the public the real solution of this question, will be to my mind a public benefactor; and when that time comes, and the successful system is laid before you, and you can put your wires underground at a reasonable expense for plant and maintenance, there is not a man engaged in this line of business but will hail that with as much joy as will those whose æsthetic tastes are shocked by the telegraph wires and posts in the streets of the city. (Applause.)

Mr. Weeks—In relation to what has been said I would like to add a word, and it is this, that the attitude of the people toward overhead wires reminds me of the familiar quotation, "Whether 'tis better to bear the ills we have, or fly to others that we know not of." It seems to me they do not stop to think of the consequences of placing electrical wires underground. Take our own city, for instance, where we now have a gas company and water company with rights to tear up the pavements of the streets and lay down their mains, in addition to a very expensive sewer system. Now, to compel three telegraph companies, two district companies, an electric light company and a telephone company, all to place their wires underground, giving them rights to go upon the streets, alleys and avenues of the city and to tear up the pavements, it seems to me that if the people sanction that, they have forgotten or do not think of the consequences of such action. The sanitary view of the matter is a very important one. We would have all sorts of fevers or malaria there, and with our narrow streets and rapidly increasing business, our thoroughfares would become impassable, and with electric companies, the placing of the wires underground would be but the beginning of the nuisance, because whenever there was trouble there would be the necessity for extensive excavation. I endorse all that our president has said in regard to waiting. I think that is our true position. We should wait until there has been a suitable system found, and it has been demonstrated to be such. Then, when that time comes, I will favor an underground system, provided the people, after an intelligent view of the objections to it, conclude that the objections to the aerial system are sufficient to warrant them in putting up with the others.

Mr. Ralph W. Pope—I would like to say one word touching this question about the attitude of the people. I think that that has been misunderstood. The way I have looked at it all the time is that the press, under some mysterious influence—we may not know exactly what it is, but we know it is there—has been very industriously manufacturing this public opinion and advertising it; and as an example of that, just before leaving New York on a tour of inspection in connection with this business, I saw in the *Times* of that city a statement to the effect that while the commissioners of New York were wrestling with this problem, Washington and Philadelphia had already placed their wires underground, and we started out and found fully as many wires overhead in proportion to the size of those cities as there were in New York. A similar state of affairs existed in Chicago, although I believe some of the wires were to be taken down at the time I was there; but the facts were there. Instead of Washington and Philadelphia having buried all their wires, it was a pretty well understood fact when they came to cipher the thing down, that there were actually more miles of wires underground in New York city than there were in either of the cities we visited. There had been underground work undertaken by the telephone company and the Western Union company; and although none had been done by the arc lighting companies, there was an extensive system of incandescent lighting wires there, so that instead of being behind, New York was actually ahead. Of course it is generally understood by citizens familiar with the streets of New York that a great many wires are over-

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head yet. Another thing not generally understood by the casual promenader of the cities, is that although the surface of the street may give you the impression that there is lots of room below, when you see an excavation made there, and see the net-work of pipes crossing and re-crossing, mains, branches and sewers, it appears quite a difficult problem to find plenty of room in the streets of New York, that is, in the down-town streets, where the problem of burying the wires is, of course, more perplexing than it is up-town. But up-town it is a financial question. There are not enough wires existing to make it worth while to put them underground. They are no nuisance, and the new manager of the telephone company finds that there are practically no telephones above Thirty-fourth street.

Mr. Henry W. Pope—I had the pleasure of serving on this New York underground committee some time ago. At the corner of Broadway and Wall street, in the city of New York, there are 45 different underground structures. Now, this committee went pretty thoroughly into the subject, and they came to the conclusion that about the only thing that could be used in the city of New York was a tunnel; and I believe because they made such a recommendation as that, it was given out in the papers that they had been influenced in one way or another to make such a report. Nevertheless, I think that anybody who has looked into the subject comes to the same conclusion. Now, a very similar thing in connection with this matter—in London, where they have had this underground system a great many years, they have a great many housetop wires, and it seems to me that in that country, if the thing had been entirely practicable, they would have refused to have granted any such permission.

Mr. Cooper—As I understand it, there is not at the present time any question before the convention, for the reason that all papers similar to Mr. Pope's, and his among them, are accepted and placed on file by the association. I would therefore offer the following resolution :

Resolved, That it be adopted as the sense of the National Electric Light Association, that up to the present time there has been no system of underground wires that recommends itself for adoption by the electric light companies of America; and that unless something more feasible is presented, that we earnestly protest against any enforcement of an underground system until it is proved beyond doubt that by such adoption the usefulness or life of the electric companies is not jeopardized; and that we believe that up to the present time all the underground systems are more or less experimental, and that it is an injustice to expect the electric light companies to adopt any system that has not proved itself practicable, not only in the electric but in any sense of the word.

Mr. Hotchkiss—I suggested to the president the filing of the approval of the report submitted by Mr. Pope. The resolution, as presented by Mr. Cooper, I do not think should be placed upon record. The question is not one of means, ways or ability. It is a question of cost, gentlemen. It will pay some men in certain localities to put up a 14-story building, and others to build a 1-story wooden shed. Some men dig a cellar 4 stories under the sidewalk; others have none. If you gentlemen of the electric light association can receive an adequate return for the service that you give to the public or to your customers, you are warranted in putting your wires underground. If you cannot get such a return, and your income will not permit you to make the expenditure, that is the only question you have got to decide. Science and ability will give you the means of quickly satisfying your wants.

Mr. Cooper—That is just the point that is meant to be covered by my resolution. As I understand this underground question, it is an enforcement of the 14-story building that Mr. Hotchkiss speaks of, with five stories underground where one story would do; and I say we do not want to be forced to build such a building unless it is absolutely necessary.

Mr. King—Can Mr. Pope tell us to what extent electric light wires are run through tunnels in Chicago?

Mr. Ralph W. Pope—There were two gentlemen from Chicago associated with me on the work of this committee, and I relied upon them to give some further information to the convention in regard to that fact that Mr. King desires information upon. Those gentlemen are not present, and I can only speak from recollection, without having thoroughly gone into it. As we stood at one of the street corners in Chicago, I was told that there were eight different arc light systems that could be seen in operation from that point. Whether that is so or not, I cannot say, of course, not being familiar with them. There are certainly several large systems in operation there, but they are not carried out to the same extent that they are in other cities of the same size. They are more local in their character—isolated plants. I presume that some of the gentlemen present—Mr. Hotchkiss or Mr. Callender, perhaps—who have done some underground work there, can give you the information you desire.

Mr. King—As a rule, western men tell the truth; but occasionally you come across a man who does not. Now, when I am at home I learn that in the east the wires are buried; when I am in the east I learn that in the west the wires are buried. I came through Chicago the other day, and while there I met a gentleman who was in the electric light business. He tells me as a matter of fact—I presume the members of the convention know it—that there is no public lighting done in Chicago, no central system of lighting, and that lighting there is done by isolated plants. He tells me that there is only one electric light company who have put wires in the conduit about which we hear so much, and that company, I understood, when I came through Chicago, was in the hands of the sheriff. Occasionally in crossing a street any of these parties must run their wire through a conduit of some kind, and as near as I can ascertain that is all the underground business there is in Chicago.

Upon motion of Mr. Weeks, the resolution of Mr. Cooper was referred.

A communication from Mr. Charles J. Vanderpoele was read by the secretary regarding progress in the development of electric railways. See page 95.

Mr. Allen V. Garratt, representing the Chemical Electric Light and Power Co., of Boston, then addressed the convention upon the subject of electric lighting by primary batteries, substantially as follows:

In the present state of the art, it is not becoming in any man to stand upon the floor of this convention and claim to do with a primary battery that which can be done with a good dynamo machine; but as you know right well, the question is not always how much electric light can you produce within economic figures, but you are oftentimes asked how little light can you furnish from an isolated plant at a price which consumers will pay?

This is precisely the question which I am prepared to answer. A primary battery capable of successfully lighting for a number of hundred hours a single incandescent lamp, or if necessary, a score of them, is not an invention to be put aside as wholly insignificant.

I speak conservatively when I say that it makes not only possible, but feasible, the electric lighting of a single house, a yacht, a parlor or sleeping car, or even a man's own private carriage. It also places at the disposal of every physician and surgeon a light always ready and requiring but little care, with which he can explore the interior of the human body. I need not suggest other uses for such a light: they suggest themselves to every one. This is a field of electric lighting which is out of the reach of the dynamo machine.

The Chemical Electric Light and Power Co. of Boston, of which I am the representative, is to-day putting out plants for the purposes which I have enumerated. It controls by letters patent the use in a voltaic battery of those chemicals which alone make possible practical results.

Heretofore a battery which could maintain an electric light for 20 hours, was looked upon as phenomenal. The Chemical Electric Light and Power Co have placed a plant in the New York Mutual Life Insurance building of Boston, which gives the elevator car 800 hours of good light, with one charge of battery solution. We are furnishing light at prices which we find the consumers are willing to pay.

I have intentionally refrained from going into the details of construction of our battery or the composition of our solutions. I should not feel justified in occupying the floor of this convention for any such purpose. I wish simply to say that we have no secrets, and the structure of our battery and the chemicals which we use are at all times open to inspection. The time has gone by for any one to claim to produce electricity or electric light for the public in any way which does not appeal to the good judgment and common sense of practical men who are skilled in this particular branch of applied science.

I will not longer take your time with this matter. In closing I wish to say that it has been to me a pleasure to bring before the National Electric Light Association the first practical device for producing the electric light in commercial quantities and within economic figures, by purely chemical means, without the intervention of any mechanical force whatever.

Mr. Weeks—The legal phase of our business is something that has been overlooked so far; that is, the legal relations of electric light companies to the patent office and the communities in which they operate, etc. In order to bring that matter before the association and put it in proper shape, I offer this resolution :

Resolved, That a committee of three be appointed by the chair to consider the legal relation of electric lighting to insurance; the legal relation of electric light companies to the public; the legal relation of electric light companies to telephone and telegraph companies; and the relation of electric light companies to the patent system.

Adopted.

Arthur Steuart, of Baltimore; A. J. De Camp, of Philadelphia, and Ralph W. Pope, of New York, were appointed as that committee.

The convention then adjourned until Friday at 10 A. M.

MORNING SESSION, FRIDAY, FEBRUARY 12TH.

The meeting was called to order at 10:15 A. M. by the president.

The secretary read the following proposed amendment to the by-laws :

" The committee offers the following substitute for Article 4 : ' The officers of this convention shall be a president, two vice-presidents, a secretary and treasurer, and six members as an

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executive committee, four of whom shall constitute a quorum. All officers shall be elected by ballot for one year or until their successors be elected and qualify, except the secretary, who shall be appointed by the president; all vacancies to be filled by the executive committee.' " Adopted.

The secretary read a letter from the Brazilian minister to the United States, acknowledging an invitation to be present at the convention, and expressing regret at his inability to attend.

Mr. Weeks presented the following report on the resolution offered by Mr. Cooper:

"Your committee makes the following report:

Resolved, That it is the sense of this association that no legislation looking to the placing of wires under ground should be enforced until it has been proven beyond doubt that by such an act the usefulness or life of the electric light companies is not jeopardized; and further, that it is the sense of this association that up to the present time no such underground system has been put in practical operation.

CHARLES COOPER,
FRANK RIDLON,
E. R. WEEKS,
Committee.

The resolution proposed by the committee was adopted.

Mr. E. R. Weeks then read a paper on "Operating Expenses." See page 90.

Dr. Otto A. Moses then addressed the convention on the question of incandescent lighting, with explanatory references to a lamp devised for that purpose, which he exhibited. See page 101.

The President—Dr. Duncan, chairman of the committee on life tests of incandescent lamps instituted by the Franklin Institute, of Philadelphia, is present, and we would be glad to hear from him on the subject.

Dr. Duncan—I am utterly unprepared to say anything about it, and my knowledge on the subject is very slight compared with Dr. Moses. But it is a subject in which I take much interest, and I have had some opportunities to judge of the life and efficiency of the incandescent lamp. I would say, in the first place, that the tendency has been to increase the tension, and therefore to decrease the size of the conductors. The cost of incandescent lighting, the great part of it, is in the conductors necessary to carry the very large currents which have been used with the low tension, and lately a great deal of investigation has been made in the direction of increasing the resistance of the conductors. How far the incandescent light can be developed, and how much it will interfere with arc lighting, of course we cannot tell. Within the last two or three years some parties have been inventing lamps of great power which it seems possible will still further be developed to the extent of taking a good part of the street lighting. I do not know how far that will go, but there are a good many difficulties in incandescent lamps which are very hard to get rid of. After a lamp has been used for a long time, the globe is blackened from the particles of carbon flying against the globe, and that of course decreases the efficiency of the lamp. Another defect is, as Dr. Moses said, a change in the structure of the carbon after it has run for a great many hours. I have examined carbons under a powerful microscope, and find that after a while these carbons made of natural fibre become crystalline in structure, and finally, after a few more hours they go. The most successful carbons so far made seem to be of fibrous material. Any homogeneous carbon has up to the present lacked the life element. Carbons that have been made of materials that have not had this fibrous structure, have not lasted very long. I do not know whether any lamp has been made, built up artificially that way. But one advantage incandescent has at present over arc lighting is in the greater possible efficiency of the low potential dynamo. In a dynamo where the potential is not more than 150 volts, the losses are very much less, and therefore the efficiency is possibly greater. You have the loss due to the induction currents in the armature, but the loss is less in the low tension machine, and there is also less possibility of burning out. If you had an arc machine made on the Siemens plan, where the currents cross each other, there is always this possibility of jarring the insulation when it is run at too great power and when it is run into very high tension, but with a low tension machine of course there is much less possibility of that effect. For that reason it is probably better to have arc machines of the Gramme type, and incandescent machines of the Siemens type. The latter affords some few advantages for mechanical construction. The work done at the Franklin Institute consisted of tests of lamps and of dynamo machines. The lamps were tested for efficiency, and were afterwards tested for life. Some of them lasted beyond the test. The efficiency tests were made with a great deal of care. The results hardly came up to the expectation of a good many people interested in the incandescent lamp. Mr. Preece made the statement, when he was last here, that they had lamps in England that would give a candle-power for an expenditure of 2½ volts, and yet have very long life. But we found generally that lamps with the greatest efficiency lasted the shortest time. Lamps of long life running into comparatively low tension. Lamps of low efficiency usually have long life. There were two lamps which were very irregular; they seemed to be in the experimental stage. They were very efficient, and some of them had very long life, but they seemed experimental, and there were a good many evidences during the tests that the thing was in a transition state. The people were always making changes in the treating of carbons and in the arrangements of details. In most of the later lamps the carbons are very heavily treated by a hydrocarbon. In one make of lamps we tested, there seemed to be a very heavy treatment of hydrocarbon. The makers would not tell the process. The result of the test to some extent was unsatisfactory; that is, they did not test long enough to put out all the lamps. The lamps were all put in at about the same potential, so we could not judge of the variation of the light with the potential. We could not do it under the provisions of the code which was drawn up. As for the tests of dynamos made after the lamp tests, the only two systems we tested were the Edison and the Weston systems. They are both built on about the same principle of course, and both machines were beautifully finished mechanically. In one machine we tested—a 400 ampère machine, weighing four tons, I think—you could turn the armature around and it would go around half a dozen times after you started it. These machines gave a very high efficiency, and showed an almost entire absence of self-induction. There was a very small loss due to the pole pieces, and another small loss due to self-induction. But the machines ran with comparatively no sparking—in fact, no sparking at all. We ran the machines for about ten hours on full load, and it took at least ten hours to heat them, and sometimes they would continue during the experiment, lasting about five or six hours. But the efficiency on the different loads was varied a good deal. It seemed that the loss in horse-power was about constant; that is, if it lost two horse-power on a full load, it lost about two horse-power on a half load. Of course that was a greater percentage of the total power, and the efficiency fell with the small load; but the potential being constant and the revolutions being the same, the induced currents in the armature would be the same, and the friction the same, and there would be only a difference of self-induction, and it made the loss constant. But I would say, in arc lighting machines there would be this advantage of having the self-induction very great. In order to get a high tension, of course you have to have a number of windings, and however you arrange those you have this effect of self-induction. For that reason one would suppose the incandescent machine would be preferable. There were some criticisms on the tests, I believe, although we did not see them until a day or two ago, about the friction of the armature being very small. The machines were coupled directly to the dynamometer, and in that way all the weight was taken off the bearings, and at the same time the oil was allowed to get all around. Now, as to the difference between machines run directly that way, and run with a belt: There was a pulley on the dynamometer whose friction we obtained after each test. The pulley weighed about 100 pounds, and the friction of the pulley was over a horse-power, while the friction of the dynamometer—the armature weighing, perhaps, 1,500 pounds—was only about 4-10ths of a horse-power, due to the fact, of course, that the pulley was pulled up against the bearing, and where it pulled up there was this heavy pressure on it, and the oil could not get in there; while with the armature running with this universal coupling, the oil could get all around it. I think that is about all I can say about tests.

Mr. Upton—It seems to me that almost every one who came out behind there is kicking. Now, I would like to know what lamp did show the most efficiency and lasted the longest number of hours?

Dr. Duncan—The lamp that showed the most efficiency did not last the longest number of hours. The lamp that lasted the longest number of hours had the least efficiency. The life of the Edison lamp was very satisfactory, but the efficiency was very small. There were two or three lamps that came out very well. I do not like to bring out instances, but if you ask for them I will give them. The Weston lamps did not come out well. Mr. Weston says there was a mistake, and we were going to test some more, but he did not send them in time for the test; but the paper lamps that were sent came out very well in the test. The White lamp, of Boston, came out very well. The resistance was very remarkable. With the same potential the candle-power ran up very fast for the first three or four days, and afterwards ran down, and on the whole they were quite satisfactory, although irregular. In fact, all the lamps came out pretty well. But in an article I saw this morning by Mr. Hering, in THE ELECTRICIAN AND ELECTRICAL ENGINEER, he compared the different kinds of lamps and made a table; but I have not tabulated the results at all, and so I cannot say as to them. But no lamp showed both great efficiency and long life. They seemed to part there.

Dr. Moses—As that is probably one of the most interesting features of incandescent lighting I would like to emphasize to the convention that those things are somewhat in the control of the manufacturer. As we heard yesterday, in the discussion on steam engines, there are some cases where it is better to use high or low pressure, fast or slow running engines, according to the circumstances. The first circumstance that must be considered is that the manufacturer goes in for the object of making money, and the one who produces a lamp with the greatest efficiency and the greatest life does not always make the most money. His lamps have to burn out or his business would have to stop.

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Now, they can make them in some respects a great deal better than they do make them, and when the time comes that people will pay a hundred dollars a piece for lamps that last forever, then we will have lamps of perfect efficiency and economy.

Mr. Smith, of Jamestown, N. Y.—I would like to ask Dr. Moses if the life of an incandescent lamp run on an arc circuit from a high potential is necessarily shorter than the light of an incandescent lamp run from an incandescent machine, and if so, why?

Dr. Moses—There is only one reason, because lamps to be run successfully should be run at uniform potentials. A lamp can only bear a certain amount of current. It is calculated for that and should be invariably run at that. If a man has regular habits and goes to bed at nine and gets up at seven, and does not have any moral or religious or political troubles in the world, he will live a very long time. So with an incandescent lamp. But an arc light is a curiously and a wonderfully made thing, and if you observe incandescent lamps on arc light circuits you will find them running at a much higher electromotive force than they ought to run. This very subject that was brought up before of the deposition of carbons at high temperatures can be brought to apply to that. You heat the carbon to a much higher temperature than it was intended to bear, to a point at which it loses some of its hydro-carbon substance. Then it becomes less in resistance. There is more current passes at that point, and in that way you disintegrate the lamp and destroy it. If you could afford to have an apparatus such as that seen last evening in the president's rooms, where you have a series of arrangements of incandescent lamps, and you can by throwing in corresponding resistance in case of the destruction of one of those lamps, compensate for it and keep the lamps at a constant electromotive force. In that way it would be possible to run incandescent lamps in arc light circuits. I would like to call the attention of the members to that apparatus upstairs. It is made by a meritorious young man, Mr. Brown, and has some excellent points about it.

Mr. Smith—My difficulty has been this. I am running incandescent lights on an arc light circuit. They are controlled by a Brush automatic cut-off, which is very efficient so far as it goes. The current is so steady that you cannot see by the eye that there is any difference in the lamps. What I want to know is whether there is something in the nature of the high potential current which destroys the lamp sooner than the low potential current. I think that the objection you raise is easily understood, but in our case it does not apply, because the lamp does not flicker. If one breaks, the cut-off goes into operation I cannot see anything else in it, so far as the nature of the unsteadiness of the current is concerned. There must be something more besides that.

Dr. Moses—I presume that is due to the fact that there is a greater pitch to the electrical wave, if I may be permitted to use that expression. If you are using a current of high electromotive force your carbons become highly incandescent and there are variations that are imperceptible to the eye. But, that those changes take place I think is theoretically quite possible. The carbon is in a plastic condition and heated to an enormously high temperature. It is in vacuo; consequently the radiations are not so rapid, and any changes of the kind, I think, would not be so very serious, because the temperature of the carbons would not change rapidly enough during the intervals in those operations to bring about that disintegrating effect. It is a curious phenomenon. It takes time, however, to discuss it. Is it your experience that those lamps do not last as long as those that run on lower potential machines?

Mr. Smith—My experience in incandescent lighting on arc light circuits has not been a profitable one. In one case we burned out 14 lamps, at a dollar a piece, in one month, where our income from those lamps was six dollars a month.

Dr. Moses—At the last meeting I called attention to the fact that I did not think that up to that time there had been a sufficient advance made to induce people to introduce incandescent lights on arc light circuits. I deprecated it because the art had not sufficiently advanced. You are dealing with very high potential currents and you are using very delicate bridges, and why should you charge the whole of your current through those small bridges if you can get light economically in any other way? I think it injures both the arc light and the incandescent light business to do it. Anything that prevents the light from being constant is doing an injury to our electric light interests. A very slight shock can paralyze an incandescent light. You should not take so delicate a piece of apparatus as that and put it on a current of such enormous proportions unless you have a perfect regulating machine.

The President—Mr. Swift, of the Brush Electric Light Company of Cleveland, is present, and I think that company is the one which inaugurated the system of putting incandescent and arc lights on the same circuits. Perhaps he can answer the gentleman's question.

Mr. Swift—The company that I am connected with does not furnish the lamps. I should have to refer you to the Swan Lamp Manufacturing Co.

Mr. De Camp—I wish I could get out of my scrapes as easily as that.

The President—That is true, and sounds very well to the gentlemen here who do not represent subordinate companies of the Brush system. The officers of the Swan company are the officers of the Brush company. The Swan company is in the Brush manufactory. The difference between the Brush company and the Swan company in Cleveland, under my observation, was a partition of pine boards an inch thick.

Mr. Swift—In reference to what you state I will say that the main point is that it lacks the elements of truth. The officers of the Brush company and the Swan company are not the same. Mr. Stockwell, who was manager of the Brush company, is not even a director of the Swan, and I am not even a director or a stockholder of the Swan, so I cannot be expected to answer the question.

Mr. Smith—I think I ought to say that the lamps vary a good deal in quality. Some of the first lamps we got lasted much longer. I do not think it is due to inequality of the action of the machine. I should say, in fairness to Mr. Swift, that there is no fault to find in the current of the machine. The cushioning arrangement of the machine certainly does keep the current steady, so that we have the point of our ampère meter at one all the time. If it lags a little bit in action the man assists it.

Dr. Moses—I would like to mention to the gentleman that according to the highest authority, Professor Helmholtz, the eye is a very imperfect instrument, and in the second place, if you wish to see how quiet and calm the effects of a disrupted current are, take any of the Geissler tubes and you will see stridæ absolutely motionless, and yet we know that the current is being disrupted hundreds of times a second. So that the eye is no instrument to be used as a criterion.

Mr. Smith—Is not the ampère meter reliable?

Dr. Moses—Not at all. It cannot begin to register those variations of current. The inertia of the needle is such that it may have been acted upon a hundred times before it will move once.

Mr. Smith—The ampère meter that I have is a very crude affair, but the needle is in a state of tremor all the time.

Dr. Moses—I am quite sure that we could receive considerable instruction and delectation from Professor Rowland on this very subject, if he would give the convention some idea of the methods that he employs for registering variations in currents. In the course of his very extensive theoretical investigations he must have employed the most delicate apparatus for it.

Mr. Morrison—I would like to ask Dr. Moses and Prof. Rowland whether they agree with the statements made by Dr. Duncan, that all lamps come under one rule, namely, that a lamp by whatever it was increased in efficiency was diminished in life.

Prof. Rowland—The theoretical efficiency of a lamp depends only on the temperature. It makes no difference what the shape of the carbon is or anything of that sort. It merely depends on the temperature at which the lamp is heated. For instance, you can very readily, from the distribution of heat in the solar spectrum, determine what the efficiency of the lamp would be. I have done that. I have not got the figures here now. I calculated it at one time and it came out a very high efficiency indeed, because when the current passes through the carbon the heat is generated in proportion to the energy of the current. That heat is radiated out in the form of both light and radiant heat, and the greater the proportion of light, the more efficient is the lamp Therefore, the higher the temperature the more efficient is the lamps; and so far as that goes, it makes no difference whatever with regard to the kind of lamp; it only depends on the temperature of the carbon. At the same time it is possible with some other substances besides carbon to radiate more light in proportion to the heat. I can not say but what by coating the carbon of the incandescent lamp with some substance—I would not be able to suggest what it would be—it might be found by experiment that the efficiency of the lamp might be increased. I know of no such substance. Nearly all substances become red hot at the same temperature. I do not know any substance which becomes red hot sooner than another substance. In ordinary physics it is stated they all become red hot at the same time. If that is so, it is to be supposed that the proportion of radiant light and heat would be about the same. If that is so, the efficiency of the lamp would only depend on the temperature. But I think very likely you might find some substances which, by coating the carbon with, you might get more light.

Mr. Upton—I am not an electrician. I am glad I am not. But I had a little experience in Washington looking at these things. I have yet to find any success financially in any incandescent lights running off arc light circuits. I talked with both the Brush and Thomson-Houston people. The latter are now getting out an independent machine to run at low potential. I think the universal opinion through New England is that incandescent lights off arc light circuits are a failure.

Dr. Moses—It has been suggested to me that this is largely a commercial question we are considering. The professor has kindly undertaken to look at it from the theoretic standpoint that underlies it all. Yet at the same time it seems to me he assumes that he is using a perfectly homogeneous conductor; but we know practically that all the different materials that are used in the manufacture of the incandescent light carbons vary in their tensile strength and in the diameter of the fibres of which they

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are composed, all of which are things that concern the economy of the lamp from a commercial point of view. So if he would allow me to supplement what he has said by an illustration, I think his remarks will enter as deeply as they ought to enter into the minds of the convention. If you imagine a bamboo fibre, the substance of which Edison makes his lamps, and get a cross section of it, you will find that it has ten fibres. In the manufacture of the incandescent lamp he has to divide those fibres, because they are not absolutely parallel. Now, if in the process of dividing those fibres you cut some of them, why you discover that the resistance of that particular lamp varies from the normal. It is very reasonable too. Just imagine it to be ten wires joined together. In the process of shearing you may cut one of those, and you have only nine little wires left, and so on. When you have, in order to increase the commercial efficiency of the lamp, brought it down to the small dimensions, you have there only five or six wires to conduct the current. You have diminished it by one-half to be sure, but you have also cut one of those fibres. That relation in the first case is as 1 to 10; in the second case as 1 to 5; so that, the mechanical difficulties being overcome, you are increasing the efficiency of the lamp by diminishing the diameter of the conductor. I simply say, that in explanation of what Prof. Rowland has remarked, because it might lead us to think it was simply a question of temperature. He is perfectly correct in what he says. He assumes a perfectly homogeneous conductor.

Prof. Rowland—I was not speaking with regard to the life of the lamp. I was speaking with respect to the amount of light we are getting from a certain amount of electrical energy, and my remarks were perfectly exact in regard to that. Of course, the question with practical men is to find an element that will stand the highest temperature for the longest time. That will be the solution of the problem.

Mr. Morrison—That is the question I asked, if you will allow me. By however much you add to the efficiency of the lamp you decrease the duration of the lamp.

Prof. Rowland—That would naturally be so, because if the efficiency is higher, the higher the temperature, and of course the carbons will not stand it. It stands a low temperature very well, and the higher the temperature the less it will stand; so that in all cases the higher the efficiency the less time the lamp will last. At the same time, of course, one cannot say that a paper carbon would not last longer or shorter than a bamboo carbon. I suppose it is a question of experiment which of those carbons would last the longest. I think that the true method would be to test with a lamp so as to give the same efficiency in all cases. I think that would be the proper method of experiment to find out which had the most efficiency and lasted the longest; because if they have the same efficiency they have practically the same temperature, and that would give you the lamp which is the best commercially.

Mr. Ridlon—I would like to ask the gentleman one question. I have noticed in some incandescent lamps that the lamp goes out instantly when the carbon is destroyed, in others the lamp is blackened up. I would like to ask the question whether that is a different kind of carbon. Is one carbon more apt to do that than another?

Prof. Rowland—I think that it would depend very decidedly on the kind of carbon, because carbon varies so much, from the soft charcoal down to the diamond; and it evidently would depend upon the degree of hardness, or possibly the amount of gas that remains in the globe. That evidently plays a very important part in the light of a lamp.

Mr. Ridlon—I have noticed, in an Edison lamp particularly, that it lights up for some time before the carbon is destroyed.

Prof. Rowland—That, I understand, is one of the practical disadvantages of all these lamps. It may possibly be gotten rid of at some time.

Mr. Kerr—I am not a light maker or an electrician; but there is something that has come up here that is very interesting to me. As I understand it, it is stated that the life of an incandescent lamp, providing the carbon is homogeneous, is chiefly proportioned to its temperature.

Prof. Rowland—Well, I suppose that the temperature of the fibre would not be the same everywhere if it was not homogeneous—assuming that the temperature of the fibre is the same everywhere.

Mr. Kerr—The point I wished to make was simply this. If as we go on increasing our temperatures in carbon, we find we are getting a shorter durability of this carbon, suppose we do that for 2,000 degrees. That does not establish the law that if we went to 3,000 degrees it would be still less durable. I wish to relate an incident in the process of steel manufacture. In the casting of steel ingots it is necessary to use something to prevent the sinking of the ingot. The thing that is used is white-hot charcoal. Charcoal is put in a graphite crucible, hermetically sealed, and is heated up to absolute whiteness. When thus heated you can kick the cover off and just turn it over like white-hot sand. Now I was at a steel works one day when an accident had just occurred. They had turned a graphite crucible and knocked off the cover, and two men were injured. The carbon in the crucible seemed all to go instantly out. It was heated to 1,200 or 1,500 degrees. That is about a good redness, I believe. Up in the neighborhood of 3,000 degrees the carbon will not ignite with air. You can see all you want of that right there every day. Now it is not fair to assume that carbon heated to an enormous temperature is necessarily more combustible: because there is the case where the softest carbon we have at a very high temperature does not combine with the air. Consequently I would not admit that the life of a lamp was increased by raising the temperature beyond a certain point. The probability is that we have another outgrowth of carbon at that point.

Prof. Rowland—I would like to inquire how he got the carbon at that temperature. I supposed that heat was generally produced by the burning of carbon or perhaps the gas. I imagined that the temperature of ordinary furnaces was produced in that way. Of course one might possibly get it at that temperature by putting it in the sun perhaps.

Mr. Kerr—You simply wish to know how we got the carbon heated. Simply in that steel furnace; it is put in a graphite crucible; I am not saying anything definite about temperatures: I am only assuming certain temperatures. It is white heat, however, and as I understand, that is about 2,500 degrees.

Prof. Rowland—I do not suppose that that is a point in electric lighting, because it is a fact I understand that the higher the wires are heated the less time they last. I supposed that was an accepted fact in electric lighting, that the higher the temperature you get the carbon, the less time the lamp will last.

The President—I think this is what Mr. Kerr is driving at. Mr. Kerr means to say that in the one case the pulverized charcoal, when brought up to a red heat, and the crucible opened at that temperature, the carbon passed off in the dust.

Mr. Kerr—It just ignited with the air.

The President—Just went off the same as a filament in a lamp. Now he goes on to say when a greater heat had been reached—a white heat—that instead of its passing away, that you could take a spoon and could handle it in that way, and no perceptible change would take place, and he draws the inference that the ground heretofore accepted as the proper one may be erroneous.

Mr. Kerr—Yes, sir, that is it exactly.

Dr. Duncan—I said that with the lamps we tested those of the greatest efficiency had the shortest life; but if that were true generally, then there would be an end to improvements in incandescent lights, because you would have to sacrifice one or the other. With the same lamp the life depends entirely on the current used, and the light increases very rapidly as you increase the current. As far as different kinds of carbon goes, if you increase the temperature it has to go through the form when it becomes crystalline, and at that point the carbon will give way.

Mr. Woodbury—In regard to the difference of the structure of carbons at very high temperatures, Mr. Edison made some investigations upon that point by putting a screen in the middle of the horseshoe of the Edison lamp, and where the current was running through the filament noted the deflections of a galvanometer, showing the difference of an electrical connection between one of the wires to the lamp and the wire from the platinum screen in the middle of the lamp, and he increased the current with increments until the lamp got up to something like 30 candle power, and then the deflection would diminish, seeming to be a reversed condition. Mr. Edison, at the time of showing it to me, advanced the hypothesis that it was quite probably due to the fact of the carbon changing in that temperature from an electro-positive to an electro-negative substance. In regard to the question of the plastic state of the carbon in the crucible, is it possible it was heated up beyond the point of temperature of dissociation? Was it heated by a gas flame containing a great deal of hydrogen, and therefore, hotter than the carbon?

Mr. Kerr—If you stopped the carbon during this process of heating at any time before it gets to a certain temperature, which I cannot fix, but we will call it 2,000 degrees, no one particle seemed to wait for another. But when you have it all heated and then cool it down, it will cool down past that point, and not make any fuss about it at all. There is this, however, to be noticed in that white-hot carbon: as you look at it in the crucible, every little while one little particle will ignite, and you will see a little spark that will go about 12 inches. Wait a little and you will see a little flickering from the top, as if something else than carbon was being consumed. But the body of it is all there.

Dr. Moses—It is an exceedingly interesting discussion, because in a collateral way it demonstrates the fact that if carbon is heated it diminishes in proportion to the increase of heat, according to a regular increment. The ordinary carbons, such as are used in incandescent lamps, shrink about one-third of their length. Now it may be that you have discovered in another way, and in that way explained the fact that we have observed in the manufacture of incandescent lights. When carbons have been heated to an exceedingly high temperature in a lamp the lamp is broken; and if that carbon be ignited in air in a gas flame you will find that it takes a much longer time for it to ignite than it would have done before, and I think it explains this phenomenon. While carbon is in an organic condition, naturally the particles of carbon are very far apart. The cell walls are separated a con-

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siderable distance, but by the contraction of the carbon in the act of making the carbon for the lamp, the carbon draws together, the cell walls get more and more approximated, and the capacity of carbon of absorbing gases ceases as the particles get closer to each other. You know that carbon will absorb many times its bulk of different gases; of ammonia gas I think it will absorb 40 times its bulk. It is a problem that you have to meet in the manufacture of incandescent lamps during the process of evacuation. That has to go on until the termination of the process. When you give it a burst of heat in order to drive out all the gases you possibly can, your lamp is finished. It is not impossible that in this last process you have so approximated the ultimate molecules of carbon that gases will no longer be absorbed. Under this process, if you please, it has become a molten mass. I think that explains the matter according to the way we look at it in the study of the incandescent light.

Prof. Rowland—Mr. President, when I spoke first I did not exactly understand the experiment, but I understand it now, I think. I am not a chemist, but I believe there are three forms of carbon: the ordinary charcoal form, the graphite form, and the diamond; and when one heats the ordinary carbon at ordinary temperature, it is different from other elements in its specific heat. But when it is heated up to a very high temperature, indeed it commences more and more to obey that law, and therefore there is a very marked change at that high temperature in the carbon. I do not know what bearing this has on the life of a lamp, because I do not know which form of carbon would last the longest; but still it must have some bearing.

Mr. Smith, of Jamestown—I would not like my experience to deter any member of the association from trying incandescent lighting on arc circuits. I believe my experience is an exception, and I believe it is caused by a bad lot of lamps. I believe that that system of lighting can be made profitable commercially. The quality of the light is there. It is just as good as an incandescent light from an incandescent machine. I believe the lamp-makers will soon get a lamp which will stand the current. A gentleman tells me he has 150 lamps working on that system, and that they are working very well. So do not go away with the idea that it cannot be done.

Mr. De Camp—I think that this question of incandescent lighting on arc circuits is one of the crazes we have got to submit to. It is new, and no electric lighting company can speak except from very short experience. It is a sad one, from all that I hear of it. It is so with me. It results in this, that it is going to make a very lively business for the lamp manufacturers. The gentleman raises a question as to the breakage. I wanted to ask Dr. Moses, but I did not wish to interrupt him, what would be the difference in the potential of an arc machine by increasing the revolutions say three or four or five in the armatures, or what would be the effect of an increase of say ten volts on a group of lamps on a circuit, that is, so far as potential is concerned. We group our lamps according to the current of our machines.

The President—One moment, Mr. De Camp. To make that plain, the machine which Mr. De Camp uses is the 26-inch armature new type of Brush machine, and upon that armature an increase in the number of revolutions in the armature operates to produce a much more marked result than in one of a smaller diameter.

Mr. De Camp—We do know this: if we have two, if we have one out of a group of seven that goes out from any cause, the others brighten up away beyond their normal condition, and we must get something in as quickly as possible to take the place of the exhausted lamp. That is done, and perhaps few lamps follow the breakage of that one, on account of the comparatively perfect operation of the cut-out that we use. But if we strike off two of them or three of them, the rest will go instantaneously. Now, it is no doubt due to the fact that we are driving through those lamps that remain the full force of our current. I do not think that anybody can have any question about that. It is easily demonstrated on our circuits. But in running a dynamo machine for a number of hours, we are liable to a change of say twenty volts if you choose, in the electromotive force of that machine, by the increased speed of your engine or decrease of it. Now I would like to know what difference that twenty volts would make on that series of lamps; that is, the twenty volts above the normal condition of the machine. Do I make myself clear?

Dr. Moses—You will have to eliminate a great many factors in that problem in order to give an approximative answer. You must entirely eliminate the internal resistance of the machine, the resistance of the line, and simply have the resistance of the lamps. Then you have a definite electromotive force between the terminals of each lamp. If you intercalate in that now any arrangement of incandescent lights, you will find between the terminals there the same electromotive force as you have in each arc light. Any change in the series would produce a correspondingly large change of electromotive force just at that point, and there you would get a correspondingly larger amount of current through the breaking of any one of those bridges for the passage of the current to the incandescent lamp arrangement. If you put in those slender filaments, you have to put in a sufficiently large number to furnish transportation for the current. You may have seen during the war armies going to the field, crowding on top, underneath, and in every direction, in the trains, but there were always accidents from that. If you crowd your cars you are bound to have accidents. Your difficulty is that you break some of the avenues, the indispensable avenues for the passage of the current. If you diminish the resistance of those bridges, you'll throw such an enormous amount of work on the fibres that they won't stand it. To obviate that you must intercalate some independent resistance which will be thrown into action by the breakage of one of these girders. You must do that; otherwise your current will put an end to itself in a very few minutes by the disruption of all the carbon avenues.

Mr. De Camp—That is my idea about it, and I do not think we shall be able yet to run a dynamo machine with such absolute perfection and keep so perfectly on a level for supplying those lamps that with the best form of cut-out that you can put on, it can act quick enough to protect the lamps against that instantaneous action that must take place when one goes out. I do not believe that can be done. It is a scientific point, and it is Greek to me.

The incandescent light is popular. It is growing in popularity. It is most popular among the business people. For certain purposes the arc light suits them; they have no objection to it. There are certain places where they have gas, and where they have no earthly use for an arc light. The distribution of the light to their offices is a great advantage to them. Its freedom from heat, and all that, is taken into consideration, and they are pleased with it. But like everybody else who gets hold af a new thing and who is highly pleased with it, they don't think much at the time of the expense, but when the novelty has worn off I contend that the public will not pay the price that we have to charge for it if we are going to get a profit out of it. I will explain myself in this way. After the romance and novelty of the incandescent light has worn off—it is simply a substitute for gas light. Now, at present the price of gas as compared with the incandescent light is very much less. But I think that people would be willing to pay a reasonable increase over gas. It takes, for instance, the same amount of power to run seven or eight or 10 incandescent lights of 15 or 16 candle-power, precisely as it does to run one arc light. You have compensation in favor of the incandescent light—the saving in carbon which you use in your arc light, presumably the saving in attendance on those lamps. That is simply a presumption, so far as our own experience goes, and so far as the experience goes of every one to whom I have spoken in this convention on this subject. Thus far the attendance on a group of incandescent lights has been more than on arc lights, because of the constant breaking of lamps and the constant renewal of them. My own experience corresponded very much with Mr. Smith's as to the breakage on those lamps. But I do not believe that we have got to a point of perfection where the consumption of lamps, the renewal of lamps in those groups will not be very much greater than the consumption of carbon in an arc lamp and the attendance on that lamp for trimming and keeping it.

Mr. H. W. Pope—I have in mind an experiment I tried in Brooklyn. I inserted an adjustable resistance in the main arc circuit, and from that I ran a shunt wire and connected my incandescent light from the shunt wire to the arc in that way, taking the incandescent lights entirely out of the arc circuits. That is to say, it would shunt the current, and only a portion of the current would get into the incandescent lights. It seems to me that the life of an incandescent lamp connected that way would be much greater.

Dr. Moses—This is a very interesting subject, and it is well for it to be thoroughly investigated here, because I think it is a matter of mutual interest to the manufacturer of incandescent lamps and to the consumer—either the actual consumer or the arc light companies. I think if it were possible to introduce the incandescent light on arc light circuits, it would enormously increase the volume of business done by the electric light companies.

Mr. De Camp says that the consumer should supply his lamp. Let us briefly consider some of the difficulties in the way of that. The consumer must get lamps of a certain electromotive force. He buys them from the company, who may or may not guarantee them. He puts them in a circuit, and his lamps may be destroyed. Therefore, it is to the interests of the arc light company to supply those lamps, and in that way to avoid that difficulty. However, let us assume, because I think it is very near solution, that the problem has been solved, and that you can put incandescent lights in arc light circuits. Let us consider what the cost of an incandescent lamp is, roughly assuming that it will burn a thousand hours at a cost of one dollar, which will make the cost of an incandescent lamp one mill per hour. If you gentlemen will make memoranda of this, and figure it out afterwards, it will lead to a solution of this question. You are willing to make a reduction, as I understand, in the cost of your electric light in order to avoid the superintendence.

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The President—One word there: a remark which you did not hear comes in. One mill per hour provided the lamp lasts 1,000 hours?

Dr. Moses—Yes.

The President—The life of a lamp, Mr. Smith, of Jamestown, claims, is not 1,000 hours.

Dr. Moses—But I assume—I ask the privilege of assuming—I think it is reasonable to suppose that because it is possible to keep the electromotive force of an arc light circuit constant, it is possible to avoid all those disruptions that come from variations in electromotive force. That I think is now about getting to be the guarantee of the Edison company. I have taken a dollar as the cost, in order to give one mill. Now, the cost of the incandescent lamp for renewals is one mill. Twenty-eight per cent. of the cost of maintaining an arc light is expended for carbons, globes, etc., which may be eliminated from the cost of maintaining the incandescent. If, for instance, to make it more complete, you charge 80 cents for the use of an arc light per diem, for what would you be able to afford to supply that arc light in case you were not called upon to maintain it?

Mr. De Camp—Aside from the carbons used in an arc lamp, the cost of attendance on it—that is, the trimming of it and the keeping it in repair, as it is on the circuit, the cost of the extraordinary repairs to the lamp by occasionally burning out, something of that kind—take that off of the original cost, then all the rest of your expenses on the group which takes that lamp's place are the same; hence that would be the cost.

Mr. Cooper—I wish Dr. Moses would take that at 25 per cent.

Dr. Moses—Assuming that 80 per cent. is the cost of an arc light per diem, and that you save 25 per cent., that would reduce the cost to about 60 cents per diem. Now, will some gentleman inform us how long an arc light will burn under those circumstances?

Mr. De Camp—I would take that on the basis of 11 hours and a half.

Dr. Moses—Eleven hours and a half for 40 cents; that is, about 3½ cents, then, per hour as the cost of the arc light. You would be receiving 3½ cents per hour for your arc light if your consumer were to take it and burn it for 11½ hours. Therefore his light would cost him 3½ cents. Now, that is the pivotal point; 3½ cents an hour would then be the cost of maintaining about eight incandescent lamps of 16 c. p.; 3½ cents for a group of eight—let me say 4 cents; 4 cents as the cost of eight lamps burning 11½ hours.

Mr. De Camp—I think I will ask you a question, if you will allow me. Take that 11½ hours, or four times 11½; that is 44 cents, that we would have to charge this customer for these lights?

Dr. Moses—Well, I beg pardon there, because you are told to take off 25 per cent., and you would then be making the same profit and you would have no trouble. Therefore I think that the thread of my argument you must admit, because it is something that is quite evident.

Mr. De Camp—Take off the 25 per cent. for that?

Dr. Moses—You would be able to have 60 cents to supply the lamp to a consumer.

Mr. De Camp—It is 4 cents an hour for a group of eight, and we run 11 hours; that would be 44 cents. That would be on an even basis with an arc plant.

Dr. Moses—Now you have eight lamps for 4 cents per hour.

Mr. De Camp—Figure that up at $1.50 a thousand.

Dr. Moses—Seventy-five cents is the cost of gas to the consumer, and he is getting the equivalent of that for 60 cents. Now, one mill per hour per lamp is 10 cents; 10 cents and 60 cents is 70 cents; he would be getting for 70 cents his incandescent light, which he would have to pay 75 cents for in gas. Now, gentlemen, I hope you will preserve those figures, so that you may go over them yourselves.

Mr. De Camp—I am not taking this on the limited number of cases where that business would be demanded and where people would pay the price which might be profitable to us.

Dr. Moses—Here is the difficulty, that that compels the consumer to use those incandescent lights all the time. Now, then, how many stores and places are there where you can use groups of eight?

Mr. De Camp—I do not think there are many; I think the business is a very limited one, indeed. You can sit down and convince a man that it is the cheapest light in the world; but after a while the novelty gets worn off; he admits what you say, but he says, "You have given me more light than I want."

Dr. Moses—You must come to the point where you supply that as long as he wants it and no more.

Mr. De Camp—If we could run directly, as a gentleman here said to me, with each lamp having its own resistance. Now, we can take a 50-light machine, for instance; and particularly if we can work on the principle of an electric lighting station on the incandescent—assuming that you have got 5,000 lamps out, yet there is no probability of more than half burning at one time. We can take a machine and put out from that 500 lights. We have a meter on that machine, and know that there has been a judicious distribution of those lamps, where people could save something by switching off a light here and there—that doesn't pay in gas, somehow. However, I like that sort of business first-rate, if we could get it in such a shape that the less we used the bigger our bills would be. That, I conceive, would open a big field to the business.

Dr. Moses—It may be possible to construct so many incandescent lights that some day we may include 40 or 50 houses in one series with a proper automatic arrangement. But until those arrangements are perfected we cannot put a series of incandescent lights through a variety of houses.

Mr. Frank Ridlon, of Boston, followed with a paper on "Carbons and Globes," in which suggestions were made as to a proper method of testing carbons, adding the following remarks as to some of the difficulties encountered.

Mr. Ridlon—Now, I will say in regard to this carbon business, that I have sent to every prominent electric lighting company for recommendations in regard to tests of carbon. I have not been able to get any positive facts or statements from any of them. I had to go to work and make up this statement from such raw and crude materials as I could pick up myself, and I would be very glad to have the question fully discussed by the superintendents and general managers of the electric lighting companies themselves. They, of course, all have different machines, giving different ampères of current, and they certainly would require different tests for their apparatus to make it perfectly satisfactory to them. The whole question seems to come down to this, that in purchasing our carbons we want to get one steady average quality of carbon, and we want all we buy, whether ten or twenty or thirty thousand, or whatever the quantity be, to come up to the standard of the quality which we supposed we were purchasing at the time we made our arrangement with the dealer or the agent of the carbon company, and I think that the greatest trouble that we have experienced in the matter of carbon is due to inattention in the matter of sorting carbons where they are manufactured. I think they have simply taken up a carbon, rolled it out on a piece of smooth iron. They have employed the cheapest class of labor in their manufacture, simply boys and girls, and assorted them with the idea that carbons that were straight should be used for firsts and carbons that were not straight should be used for seconds. It does not seem to me that that is the kind of assorting of carbons that we require. We want to be sure that all the carbons we purchase at a given price possess all the requisite qualities; that is, that there are no soft spots in them; that they are of the average amount of resistance, that is, that we can get our full complement of lamps, giving the proper amount of candle-power on those lamps from the machine less the resistance of the wires, according to the length of the circuit. In order to bring this thing up, I should suggest that those called seconds should be cut down to such a price that in making our contract it will be quite an object in sending carbons that they are all of the first quality that no seconds are mixed up with them, and if seconds are mixed up with them, that the price would have to be reduced for the second quality of carbon; that they would rather pay a good price for labor and get competent persons to do their assorting. I should be very glad to hear from the carbon men on these suggestions. We all know very well that the kind of carbon that will do for one purpose will not answer for another, and the carbon that we might use economically in the summer we certainly could not use in the winter.

Mr. Morrison—The question of carbons is a very important one to the lighting companies, and by great competition the price has been reduced from $66.50 down to the lowest figure quoted in market, $10 a thousand. This was owing simply to the sharp competition which had been engendered by the enormous profits made by the Brush company when they first put the carbons on the market The first break was made by Mr. Boulton, originally an employé of the Brush company, who, after having served with them for a certain time and observing the enormous profits that were made in that line of business, fairly presented the subject to the enterprising capitalists of Cleveland and induced them to establish a rival carbon factory. The establishment of this factory has made Mr. Boulton a benefactor to the electric light companies. Following this break came a number of other small manufacturers, so that we are to-day supplied with a $10 carbon instead of a $66.50 carbon. The information that Mr. Ridlon has gathered together would lead one to believe that the difference in the quality of the carbons is as great as the difference in the manufacturers.

That is not so. The Baltimore company has used the carbons manufactured by the Boulton company, by the Parker-Russell Manufacturing and Mining company, the Brush of course, and I think one or two others. Nearly all of them have given fair satisfaction in our service. The proof of the pudding is in the eating, they say, and the proof of this statement I am making to you lies under your observation, every night that you walk the streets of Baltimore. There are the lights, and there are the carbons which we are using to-day. We do not mix the carbons of different manufacturers upon the same circuit, because that would not be giving fair play. The defects in a lamp might possibly be attributed to the carbon itself, when the carbon would

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be all right; but if you take an entire circuit of lamps and equip them with Brush's carbon, and right along these streets here where our wires interlace, one lamp is on our No. 1 circuit, the next on No. 2, the next on No. 3, so you get four of five squares before you strike a lamp on No. 1 circuit. The entire circuit is devoted to the use of carbons of one maker. That man is going to get fairer play than if you mix him up with two or three other makers. We have adopted this plan in Baltimore, because of the enormous prices charged for carbons, and this is the result which I am placing before you. I am giving you all the information which we possess here, and if I had not been unfortunately in the chair, I should from time to time probably have had more to say. But these things are the very things which promote the life of the subordinate companies. This association is organized for the purpose of disseminating information among the subordinate companies. There is one thing which will transpire within the next twelve months, and it will be to compel fair play not only in carbons and globes, but in the matter of machinery and other supplies used by the subordinate companies from the parent companies, from whom the apparatus and supplies have been obtained. (Applause.)

You will observe that that applause comes from points where there are no electric light companies represented. Some of them are supply men who applaud. I reckon they have had their shoes pinch them there.

I do not know that I can add anything else to the question of carbons. As to the matter of globes, we have found a difficulty in obtaining a sufficient degree of promptness in supplying our orders for globes, and for this reason, then, we have bought globes from almost every manufacturer within our reach in the United States. Our principal purchases have been made from the New England lamp company, and I am glad to say we have received a fair quality of goods and fair treatment from that company. When troubles have arisen with their goods, they would hasten to rectify them. When a change in the form of a globe was needed, they would hasten to change the form of the globe. So that of the globe men we have not such serious complaints to make as we have of the carbon men.

On motion of Mr. Cooper, a committee of three was appointed to investigate the carbon question and adopt a standard.

Messrs. Cooper, Ridlon and King were named to serve as such committee. The meeting then adjourned to 4 P. M.

AFTERNOON SESSION, FRIDAY, FEBRUARY 12TH.

At the opening of the afternoon session, the secretary read the following resolution, which was unanimously adopted:

Resolved, That this association sincerely mourns the death of Mr. A. J. Holt, of Cleveland, Ohio, a highly esteemed and capable member, whose intelligent work, had he lived, would have been of great value and interest to this association.

The following preamble and resolution were also adopted:

Whereas, The last two meetings of the National Electric Light Association have been held in the east, and as the time of the next meeting is in the month of August,

Resolved, That the executive committee be requested to call the next meeting in Detroit.

The following resolution was read by the secretary:

Resolved, That the chair appoint a special committee, to be composed as far as practicable of the representatives of each system, to consider the relations of the sub companies to their respective parent companies, to act in conjunction with any existing committee which may aid them in harmonizing any differences which may arise, and bring about a more hearty co-operation, so much to be desired and so essential to the welfare of all in concern.

Adopted.

A paper on the relation of electric lighting to insurance was then read by Mr. C. J. H. Woodbury, of Boston. See page 98.

The President—Gentlemen, the paper is before you for discussion. The insurance men of Baltimore were invited to be present at this session to listen to the paper which has just been read, because of the title of the paper—the relation of electric lighting to the insurance business. If there is anything in the paper that they desire to criticise, we would be glad to hear from them.

Mr. Wilkinson—I desire to say that I think all of us appreciate very highly, indeed, Mr. Woodbury's paper, and so far as the insurance part of it is concerned, must necessarily endorse it, because his experience is perhaps the best of any man of his age in the country, and we tender our thanks to the president of the association for inviting us to be here, and to Mr. Woodbury for presenting this very interesting paper.

General James Anderson—I have listened with a great deal of pleasure to the paper; and speaking for the underwriters of Baltimore, I have to say that we are entirely in your hands, so far as electric lighting is concerned. We are not favored in the city of Baltimore as other underwriters are in larger cities than ours, where they have careful supervision and constant inspection of the wires. You are aware, sir, that we have had comparatively few fires from the electric light in Baltimore. I cannot remember more than two or three. We are perfectly satisfied that if the wires are carefully and properly introduced, and looked after almost every day—speaking from my standpoint, without any knowledge whatever of the force of the electric current—I am perfectly satisfied that they are quite as safe, if not more so, than a gas light. I have seen our bay steamers where they have the electric light, and the persons employed on them assured me that they gave a great deal more satisfaction than the gas light did. I have only to say, sir, that by carefully introducing them in warehouses and dwellings, I am satisfied, for my own part, that the electric light will be of very great advantage to us. I speak with diffidence about this matter, for I had occasion two or three years ago to speak to a gentleman in regard to the electric light, and I remarked to him that this system of electric lighting is yet in its infancy. He said, "My dear, sir, it has not been born." I as well as my colleagues here of the insurance fraternity are very grateful for the paper which the gentleman from Massachusetts has read before this convention to-day. (Applause.)

Mr. Gilbert—One matter, I think, has escaped the attention of this convention in respect to reducing the cost of producing the electric light to the local companies, and that is the matter of insurance. We have been rated in our local companies as extra hazardous, when every man in the business knows that the station is constantly under the watch of some of his employés, and that it is exactly the reverse; so that in the name of the New Haven company we sent a circular letter to about 100 of the local companies, asking for statistics regarding the rates paid for insurance, the amount insured, and any losses which might have occurred. We received replies from 31 companies. The total estimated amount of loss in case of total destruction was $1,178,000; amount of insurance carried, $481,000; premiums paid varying from three-fourths of one per cent. to four per cent. Total premium paid on the amount insured at these rates for three years—three years being the time that several of the plants said they had been in existence—amounted to $19,112.25. The total loss in three years by fires amounted to $1,000, or 7-10 of a mill on the amount insured. Were we to organize a mutual insurance company, with a governing board to consist of members of the electric light companies, we should not only be able to reduce the cost of insurance, but we should be in a position to reduce the amount of loss in this manner; that is, in case we have a loss—as I know the loss in one plant was—of $550, caused by a dye works taking fire adjoining the electric light station, then going into the four story building occupied by the electric light, and burning out three stories of it, taking the adjoining building and burning three stories of that; the insurance companies paid $550 loss. We claimed all we could, and got $550. I suppose we were to blame for making the stock companies feel that this risk was extra hazardous. In this case the actual loss, after settling, and finding that we would not go to the parent companies, was $150. Another case was caused by the explosion of a kerosene lamp in the station, which cost $100; and the third was from lighting. If the actual loss on those plants was the same as our loss in New Haven, instead of being 7-10 of a mill on the dollar, it would be about 2-10 of the amount of premium paid.

Mr. Cleveland—Residing in an insurance city, it has been very convenient for me to get information upon this plan that has been so clearly explained by Mr. Gilbert, and I am quite sure that his statements are correct. I am also sure that this association will approve his plan. It is fair to say, however, that Mr. Gilbert and his friends will not depend upon any action of this convention in regard to carrying out his plan of organizing his company. But what he desires is that this convention shall approve and take an interest in it, as I have no doubt you all will. I therefore beg leave to offer the following resolution:

Resolved, That the association endorses the plan of an organization of a mutual electric light insurance company, and that the chair appoint a committee of three to perfect such organization.

The motion was seconded.

The President—I am not sufficiently familiar with the insurance business to pass any opinion upon it, but upon general principles I am opposed to going into any business outside of that for which our association was planned. I am equally opposed to lending the name and sanction of this association to any scheme outside of the legitimate business of the association. When this question is called, therefore, I shall vote against the adoption of the resolution, for these reasons.

Mr. Woodbury—As the theme of my discourse here was on an entirely different phase of subjects, relating to electricity, and as the insurance interests that employ me do not propose to enter into this insurance, I can speak upon the subject very freely. A few weeks ago Mr. Gilbert, with some of his friends, called at our office with inquiries to know if their electric light station could be insured in the Factory Mutual Insurance Co. Our first reply was that that matter would be very undesirable, irrespective of any question as to the risk attached to an electric light station, for the risk of an electric light station isolated is very small. Our experience for 35 years, to the amount of $59,338,000, has been a loss of 11 cents and 7 mills per $100 of insurance per annum—less than one-eighth of one per cent. Now, some reference is made to this mutual insurance company. All insurance is a tax. It is the heaviest tax in this country. It is the distribution of the losses of the few to the many. The cheaper the administration of that tax can be carried out, the better it is for all

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interests. The amount can be fixed most equitably by class insurance. About 50 years ago Zachariah Allen, of Providence, built a mill in which he introduced many improvements of equipment and construction. It was the first property with a pump for fire purposes only, and it had, besides, many other original features. After the mill was finished, he submitted his plans to the president of the insurance company in Providence, and was listened to with satisfaction. At the end of his interview he said, "Now, Mr. President, you have appreciated my effort to reduce the hazard of fire in this mill; I wish you to come up to my mill and examine it for yourself, and from your experience in such matters make up your mind as to the probable hazard of that mill, and charge me a diminished rate accordingly." The president of the insurance company replied, "Mr. Allen, a cotton mill is a cotton mill, the rate is 2¼ per cent., and we have no time to go into the country to examine your Yankee notions." As a matter of fact, a contract was made between manufacturers there, by which they agreed to make special alterations and share each other's losses. An insurance company was formed on that basis. These factory mutual insurance companies have confined themselves to thoroughly protected, isolated manufacturing property of good construction, and by keeping themselves in that class they have been remarkably fortunate. They now carry a little over four per cent. in amount of all the insurance in the United States. Last year they wrote $405,500,000. Their losses by fire were 13 1-10 cents on $100. The cost of taxes and net cost of administration were about 2 cents more, making the cost of insurance 15 cents on $100. Supposing you thought fit to insure your electric light station, if you can get the owners of enough stations, not those who are merely tenants in buildings, but where you are entirely separated, as in this Brush station in Baltimore, you could certainly form a very successful company, sharing your losses, and by conducting it with economy it would be the cheapest method, undoubtedly, of protecting against fire. But there is no magical result of diminished cost in the matter of mutual insurance. The plant has to pay the average cost of the chance of destruction by fire. You make a selection of those risks, keep them together, and your chance of fire will be small.

Mr. Renshaw, Washington, D. C.—I would state that within the last year we have suffered from fire in Washington. We had our station destroyed during the last summer, and, owing to the general prejudice that insurance companies seemed to have in that locality, we carried very little insurance, and our loss was very heavy. We have now a very fine station, entirely isolated, and the risk of fire is very slight, but if that could be insured at a reasonable rate, we would be pleased to carry an insurance. I should think it would come fairly within the scope of this organization to encourage the formation of any insurance company that could reasonably insure without any prejudice; and while we may not lend ourselves to the formation of a company, I see no reason why we should not encourage Mr. Gilbert in his enterprise.

Mr. Gilbert—The thirty-one companies that I received communications from are paying an average amount of $1.65. This matter I have brought before the convention, because those who replied to the letter seemed very much interested in it.

Mr. Weeks—Our rate was fixed at $3.10 at Kansas City, and I called on the manager of the board and told him if that was to be the rate we would carry our own insurance or go outside the board. It was finally readjusted at $1.45, which rate we are now paying on our insurance.

The resolution was subsequently adopted in the following amended form:

"*Resolved*, That this association endorse the plan of an organization of a mutual electric light insurance company."

Mr. King, from the committee on nominations for officers for the ensuing year, reported as follows:

Your committee desire to say that to relieve the president of the large amount of labor which falls upon his shoulders in the absence of the executive committee, and the difficulty of getting them together when they are in widely different places, we thought it would be judicious to select a majority of the committee from localities where they may meet for consultation when desired. The list is as follows: president, J. Frank Morrison, Baltimore; vice-presidents, E. R. Weeks, of Kansas City; H. M. Cleveland, of Hartford, Connecticut; treasurer, Charles Cooper, of Brooklyn; executive committee, George S. Bowen, of Chicago; James A Corby, of St. Joseph; Frank Ridlon, of Boston; George F. Fletcher, of Dayton, Ohio; E. T. Lynch, Jr., of New York; Dr. Otto A. Moses, of New York; A. J. De Camp, of Philadelphia.

There being no other nominations, it was voted that Mr. King cast the ballot of the convention for the above ticket, which he accordingly did, and it was declared elected.

Mr. Ridlon—I would recommend that this convention adopt a bureau of information which shall be to the electric light association or its members the same as *Bradstreets* is to mercantile houses. This bureau to be in charge of the president and controlled by him. I offer this resolution:

Resolved, That the National Electric Light Association form a bureau for collecting and distributing information regarding electric light matters, which shall be under the control of the president, and necessitate the employing of a permanent secretary with a permanent office for the association. Adopted.

Mr. De Camp—There is a committee, or there will be a committee, appointed on the basis of the resolution offered here early in the meeting—a committee of conference it might be called, between the parent and sub-companies. I have heard since I have been in this convention, from time to time, of one or two instances of cut-throat business, where two companies were trying to destroy each other. That would come within the scope of this committee to which I have referred. I would like to see a resolution passed which could be called to the attention of the aggressor, expressing the sentiment of the convention as being absolutely opposed to any such method of doing business. I offer this as a suggestion, not as a resolution.

Mr. Morrison—The only case that I know of in that connection is the case of Mr. Maher, of Albany. Mr. Maher's company went to the expense of installing a plant in Albany some years ago. They had started lighting at 50 cents a lamp. The city purchased the plant necessary to do the work. There has been no question about the quality of the service. There has been no objection to the terms of the contract by the people of Albany, until within the last few weeks, as I understand, in which the Thomson-Houston have sent their agents into Albany, and are now holding a sort of Dutch auction. They are trying to bid down the electric light business—see who will bid lowest. Now I am in favor of the passage of a resolution as suggested by Mr. De Camp. Here is one of the cases of mutual insurance that I stand ready to adopt at once. I am happy to say that I have had communications with members of this association who are the chief officers of some of the subordinate companies of the Thomson-Houston system, and that these gentlemen have promised me that they will use their individual and official efforts upon their return to their respective homes, through correspondence with their parent company, to dissuade them from this attempted piracy upon the legitimate business of the electric lighting company of Albany. I know of no terms too strong, Mr. President, to use on an occasion of this kind. A set of gentlemen will go into a city. They will spend their time and labor and become the pioneers in the enterprise. They work the system up to a success. They work the plan up to a success, and they finally succeed, after overcoming various difficulties, in establishing a company. They go along until either the company is a success or a failure. If it is a failure, then they have no opposition. If it is a success, then along comes some other company, and they sing the song of "Old Sam Brace, it is my name, if you don't let me in I will break up the game." Now I want this association to put itself plain and straight on record that they will not only discountenance such action on the part of any parent company, or on the part of any one engaged in such business, but that they will use their individual and official efforts, the same as the gentlemen have promised to do who have spoken to me, to discountenance this sort of piracy on legitimate business.

The discussion was continued at considerable length by Messrs. Maher, Cleveland, Cooper, Weeks, H. W. Pope, Gilbert, Linnell, De Camp and King, all of whom denounced the methods pursued in infringing upon territory previously occupied, with the usual results of loss and trouble to all and profit to none.

In accordance with a resolution adopted the president appointed the following committee to raise funds for carrying on the bureau for the accumulation and distribution of information: Messrs. Ridlon, of Boston; Corby, of St. Joseph; Price, of New York; Martin, of New York; Bowen, of Chicago; De Camp, of Philadelphia; Cooper, of Brooklyn; Goff, of New York, and Cleveland, of Hartford.

Upon motion of Dr. Moses, MM. Marcel Deprez and Cornelius Herz, and the Baron Alphonse de Rothschild, were elected to honorary membership.

The convention then adjourned, to meet Detroit in August next.

MEMBERS, ASSOCIATES, AND VISITORS IN ATTENDANCE.

Bauer, A. H.—Viaduct Manufacturing Co., Baltimore, Md.
Brown, H. P.—Brown Electric Co., Chicago, Ill.
Beetle, George L.—American Electrical Works, New York.
Barclay, J. L.—Holmes, Booth & Haydens, New York.
Boyer, C. W.—Philadelphia, Pa.
Bryan, S. M.—Washington, D. C.
Carter, George T.—Brown Electric Co., Pittsburg, Pa.
Callender, W. M.—Callender Insulating and Waterproofing Co., New York.
Cabot, F. E.—Boston, Mass.
Candee, W. L.—Okonite Company, New York.
Cleveland, H. M.—Waterhouse Electric Mfg. Co., Hartford, Conn.
Corby, Joseph A.—St. Joseph Electric Light Co., St. Joseph, Mo.
Coughlin, W. H.—Worcester, Mass.
Dowse, W. B.—New York Insulated Wire Co., Boston, Mass.
Dickey, D. D.—Pittsburg Carbon Co., Pittsburg, Pa.
Duncan, S. A.—Allegheny County Electric Light Co., Pittsburg, Pa.
De Camp, A. J.—Brush Electric Light Co., Philadelphia, Pa.
Dorsett, D. H.—Dorsett's Underground Conduit System, Chicago, Ill.
Dam, Andrew J.—New York.
Duncan, Ensign—U. S. S. Juniata, New York.
Evans, D. C.—Brush Electric Light Co., Baltimore, Md.
English, James.—Newport Electric Illuminating Co., Newport, R. I.
Fenner, H. N.—New England Butt Co., Providence. R. I.
Fishback, L. M.—Parker-Russell Mining and Mfg. Co., St. Louis, Mo.

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Fitzgerald, W. H.—Brush Electric Light Co., Detroit, Mich.
Frost, H. P.—New Haven, Conn.
Fosdick, Frederick—Fitchburg Engine Co., Fitchburg, Mass.
Fairbanks, H. H.—Worcester Electric Light Co., Worcester, Mass.
Gilbert, F. A.—New Haven Electric Light Co., Boston, Mass.
Garratt, Allen V.—Chemical Electric Light & Power Co., Boston, Mass.
Hotchkiss, Clark B.—Kerite, New York.
Hebard, George W.—United States Electric Lighting Co., New York.
Harding, H.—Massachusetts Electric Power Co., Boston, Mass.
Hayward, A. H.—Daft Electric Railway, Baltimore, Md.
Harrington, F. W.—Western Electric Co., Chicago, Ill.
Hickley, A. S.—New London, Conn.
Kerr, W. C.—Westinghouse, Church, Kerr & Co., New York.
Keilholtz, Pierre O.—Johns Hopkins University, Baltimore, Md.
King, T. S.—Minneapolis Electric Supply Co., Minneapolis, Minn.
Linnell, H. M.—Schuyler Electric Light Co., Hartford, Conn.
Law, M. D.—Brush Electric Light Co., Philadelphia, Pa.
Libbey, E. D.—New England Glass Works, Boston, Mass.
Lynch, E. T., Jr.—United States Illuminating Co., New York.
Latshaw, F.—McKeesport Electric Light Co., McKeesport, Pa.
Maher, E. A.—Albany Electric Illuminating Co., Albany, N. Y.
Mitchell, D. L.—Taunton Electric Light Co., Taunton, Mass.
Morrison, J. F.—Southern Electric Co., Baltimore, Md.
Martin, T. C.—*The Electrical World*, New York.
Mason, Col. Fred. A.—Bridgeport Brass Co., Bridgeport, Conn.
McIntire, Chas.—Newark, N. J.
McCoubray, T., Jr.—Morrison's Electrical Works, Baltimore, Md.
Morse, Everitt—Morse & Whyte, Boston, Mass.
McGrath, W. H.—Brush Electric Light Co., New York.
Moses, Dr. Otto A.—New York.
McCay, H. K.—Baltimore, Md.
Mullen, E. S.—Thomson-Houston Electric Co., Philadelphia, Pa.
Noonan, J. F.—Paterson Electric Light Co., Paterson, N. J.
Pentz, J. A.—Porter-Allen Engine Works, Philadelphia, Pa.
Price, Charles W.—*Electrical Review*, New York.
Proal, A. B.—Viaduct Manufacturing Co., Baltimore, Md.
Pope, Ralph W.—ELECTRICIAN AND ELECTRICAL ENGINEER, New York.
Pope, H. W.—Schuyler Electric Light Co., Elizabeth, N. J.
Phillips, Eugene F.—American Electrical Works, Providence, R. I.
Porter, Geo. F.—Pittsburg Carbon Co., Pittsburg, Pa.
Reed, Henry A.—Bishop Gutta-Percha Works, New York.
Rae, T. W.—New York.
Russell, D. R.—Parker-Russell Mining & Mfg. Co., St. Louis, Mo.
Ries, E. E.—Baltimore, Md.
Rowland, Prof. H. A.—Johns Hopkins University, Baltimore, Md.
Royce, W. Fred.—Washington, D. C.
Rollins, F. W.—*Commercial Bulletin*, Boston, Mass.
Ryan, R. W.—Official Stenographer, New York.
Robinson, R. S.—Providence, R. I.
Rorison, Brainard—Jenney Electric Co., Indianapolis, Ind.
Sweet, J. E.—Syracuse, N. Y.
Stump, C. E.—*The Electrical World*, New York.
Stone, Frank G.—Ansonia Brass & Copper Co., New York.
Sims, G. C.—Armington & Sims, Providence, R. I.
Spang, H. W.—Ball Electric Light Association, Reading, Pa.
Stanley, H. S.—Bridgeport Electric Light Co., Bridgeport, Conn.
Shultz, J. A. J.—Shultz Belting Co., St. Louis, Mo.
Swift, W. F.—Brush Electric Co., Cleveland, Ohio.
Shaw, A. C.—Callender Insulating & Waterproofing Co., New York.
Thompson, C. M.—Callender Insulating & Waterproofing Co., New York.
Tuxworth, D. H.—Southern Electric Co., Baltimore, Md.
Travis, C. L.—Minneapolis Electric Supply Co., Minneapolis, Minn.
Upton, A. F.—Jarvis Engineering Co., Boston, Mass.
Woodbury, C. J. H.—Boston, Mass.
Weeks, E. R.—Kansas City Electric Light Co., Kansas City, Mo.
Worthington, George.—*Electrical Review*, New York.

MANUFACTURERS' EXHIBITS.

The line of exhibits by various dealers being confined chiefly to the class of goods used for arc lighting purposes, the display was not as extensive as at previous conventions of a different character. The latch-strings of the various representatives were hung out conspicuously however, and the best of feeling pervaded the entire assemblage, under the genial influence of Baltimore hospitality.

KERITE WIRE AND CABLES.

While no disposition to place wires underground was evinced by the members in convention assembled, the samples of cable, composed of as many as 18 arc light conductors, looked as if they were ready for the emergeney. Single kerite wires, both plain and lead-covered, with samples of submarine cable, completed the assortment, and Mr. Clark B. Hotchkiss convinced every visitor that no other wire was really adapted for their use.

THE AMERICAN ELECTRICAL WORKS OF PROVIDENCE.

Mr. Eugene F. Phillips, with his usual good taste, presented his usual excellent collection of the various electrical products of his well equipped factory. As he left Baltimore the second day of the convention, Col. Beetle looked after his interests subsequently and labored vigorously to expound the peculiar merits of the underwriters' wire, which was no doubt as good in quality as it was attractive in appearance.

BITITE WIRES AND CABLES.

The Callender Insulating and Waterproofing Company was well represented, Messrs. W. M. Callender, Thompson and Shaw being continually alert. They exhibited sections of their underground conduit as used in Washington, also various styles of wire for submarine and subterranean work.

THE OKONITE COMPANY.

The Okonite insulation, which is gaining a good reputation, was shown in connection with wires and cables for all classes of work. The armored subterranean cable, for burying near the surface of streets without requiring a conduit, was particularly admired by gentlemen residing in those parts of the country where the ground is frozen a large portion of the year.

THE BROWN AUTOMATIC CONVERTER.

The interest awakened in the problem of successfully introducing incandescent lamps upon arc circuits attracted much attention to the ingenious device of Harold P. Brown, which is now being placed on the market for this purpose. The standard size of the converter is arranged to accommodate a group of say 16 c. p. incandescent lamps, upon a circuit supplied by any of the ordinary type of arc lighting dynamos.

It is said to be so perfect in its action that the exact current for which it is adjusted will always be delivered to the lamps, thus protecting them from injury, and greatly extending their life. It is expected that further testimony as to their merits will be produced at the next convention.

CONVENTION SIDE-LIGHTS.

Fortunately for the press, but perhaps unfortunately for the public, the by-talk of a convention of this character is not expected to be reported. It is sometimes instructive, however, and on this occasion was chiefly conspicuous in praise of the good work which the association is accomplishing.

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Perhaps it was fortunate that Baltimore had been selected as the meeting place, otherwise the discussion upon the transmission of power would not have seemed of so much importance. The members are intensely practical men, and prefer to examine an actual electric railway, rather than listen to a theoretical exposition of what might be done.

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The journey to the dynamo station—thirty minutes by horse car—leads one to desire a change to some more progressive conveyance. There appears to be plenty of steam power, an 80 h. p. engine driving a couple of large generators. The engineer is on duty 18 hours, either because he is the only capable man to be had, or from motives of economy.

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The track is crooked and hilly, and as the motor goes over rough places, the rails are lighted up at night for 200 feet in each direction by electric fire from the contact wheel. There is considerable dissipation of energy, and there is also resultant work. As to the econcmy the visitors were not prepared to testify.

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With a good, straight, level track and perfected machinery, there is something to look forward to which will add greatly to the general usefulness of electricity in connection with intercommunication.

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Johns Hopkins University was an interesting spot for some of the disciples of science, and those who rambled through its narrow passages and crooked stairways, regretted that more time could not have been devoted to thorough examination of the physical laboratory, as well as other most interesting features of the institution.

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The heavy work of the convention was lightened up by many pleasant incidents, none more refreshing than the unexpected appearance of Mrs. Charles Cooper, the wife of the popular treasurer, who evinced much interest in the proceedings, graced as they were by several attractive speakers, who added renewed brilliancy to the incandescent light.

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An elegant basket of flowers was considered the most fitting testimonial by which to assure the fair visitor that her presence was appreciated, and the direct tax which was leviedf or this purpose was honored with an enthusiasm seldom evinced by members of an association when they are requested to "walk up to the captain's office" and settle their dues.

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Terrapin in Washington is not to be classified with the same dish served up under the dictum of president Morrison. A midnight supper under such auspices, made up of the various delicacies for which Maryland is famous, leads one to endorse the wisdom of the association in selecting Baltimore for its first annual convention. In every respect it was an unqualified success.

AN INTERESTING ELECTRICAL COLLECTION.

MR. JOHN HORN, now of 196 Hypolite street, Montreal, Canada, has for 25 years given careful attention to the collection and preservation of various letters, documents, prints, portraits, etc., in connection with electrical history properly arranged and mounted. He is willing to dispose of them to some person who takes an interest in such matters, or they would be a valuable addition to a scientific library.

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ELECTRIC GAS LIGHTING.

DECISION OF JUDGE WALLACE.

United States Circuit Court, Southern District of New York.

BOGART *vs.* HINDS.

WALLACE, *J.*

Infringement is alleged of the first claim of Letters Patent No. 119,561, granted to Abraham L. Bogart, October 3, 1871, for an improvement in apparatus for lighting gas jets by induced current of electricity.

The claim is:—"1. An insulated gas burner having its insulated section of or from glass or similar vitreous material substantially as and for the purpose specified."

This claim cannot be construed as a broad claim for a gas burner in an electric lighting system, having an insulated section of the material mentioned. The patentee was not the first to discover the peculiar value of such material for insulating purposes in gas burners intended for use in electric gas lighting apparatus, and the novelty of the claim would be negatived by the patent to Bean & Mumler, of June 4, 1867, and the patent to Barbarin, of June 1, 1869. On the other hand, upon correct principles of construction, the claim should not be limited to an insulated burner having all the details of construction which are described in the specification of the patent. The second claim of the patent makes various details of construction constituents of the claim

Clearly these details are not to be incorporated into the comprehensive language of the first claim.

Such a construction, in view of the prior state of the art, would also unduly narrow the scope of the real invention of the patentee.

The essential novelty of the patentee's invention consists in selecting an appropriate insulating material, and making from it the upper part of a gas burner which will serve both to support and insulate the electrical conductors, and as a gas way from the gas pipe to the place where the spark is communicated to the gas. The patent to Arnold and Irving, of March 12, 1867, shows an entire gas burner made of substantially the same material as that employed by the patentees. This gas burner, however, was made with no thought of its utility for insulating purposes in an electric lighting system. It was an ordinary gas burner. Other inventors had inserted insulating material in electric lighting burners, employing independent insulators and independent insulated sections. By substituting a burner similar to that of Arnold and Irving's, and making a slight modification in its exterior construction, so as to form a shoulder upon which the electrical conductors could be firmly and securely fastened, the patentee was enabled to dispense with the complicated parts employed by those who preceded him, and made a simple, compact and efficient burner, which would serve both as an insulator for the conductors, and a gas way from the metal pipe to the point of ignition and a firm support for the conductors. It is quite apparent that in strength, rigidity and simplicity of construction it is a much better practical burner than those which were devised by preceding inventors who were striving to make an efficient burner,

In view of the comparatively unsuccessful efforts of those who preceded him, and of the manifest improvements which resulted from the change, it is not doubted that what he did involved invention.

The language of the claim does not necessarily limit the patentee to a narrower invention than he really made, and by selecting the essential features of his improvement as described in the specification, and discarding non-essentials, it can be read so as to secure him to the extent of his invention in the light of preexisting patents and the prior state of the art.

The defendant has appropriated this invention. He has changed the mode of fastening the conductors to the burner, but they rest upon a shoulder of the insulated part of the burner which serves as a gas way from the gas pipe to the point of ignition.

The complainant is entitled to a decree.

RAILWAY TRAIN TELEGRAPHING.

Although telegraphing from moving trains has not yet become a recognized feature of railway administration, two systems have already been publicly exhibited in the vicinity of this city. William Wiley Smith is the inventor of the apparatus which has recently been applied to a train on the Staten Island railway. Messrs. Gilliland and Edison have spent considerable time in perfecting it, so that it is now considered a practicable arrangement. The inductive effect upon which it depends for action is produced by making proper connections with the metal roof of the car in which the train outfit is located. A single roof will suffice, but it is preferable to utilize several connected together.

The apparatus consists of a Morse key, telephone receivers, an electro-magnet operating a vibrating reed, an induction coil, and 10 cells of battery. The local circuit is joined up through the primary of the induction coil, the secondary wire of which is connected at one end with the earth, through the axles of the car to the track, while the other connects with the roof. These rapidly intermitted high tension pulsations leap from the roof to the wires along the roadway, and are brought through a similarly arranged circuit at the station, the telephone receivers being used in all cases, and the Morse signals read by the duration of the dots and dashes as indicated by the length of the tone. A series of metallic plates are required at the stations, connected with each wire used for the system. The line wire may also be coiled up in such a manner as to form the primary, while the office wire interwound serves as a secondary. In order to obtain good results more than one line wire is necessary, four being used on the Staten Island route. The distance from the roof to the wires is from 15 to 20 feet. The practical working of the apparatus appears to be satisfactory. The miscellaneous character of the business which it is expected will be transmitted over systems of this character, appear to demand the employment of highly skilled operators, who should give their careful attention to the service.

THE WESTINGHOUSE ELECTRIC CO.

The Westinghouse Electric Co., of Pittsburg, with $1,000,000 capital, has applied at the state department of Pennsylvania for a charter. Its incorporators are George Westinghouse, Jr., W. H. Jackson, H. H. Westinghouse, John Dalzell, John R. Mc Ginley, John Caldwell, Robert Pitcairn, all of Pittsburg, and Frank L. Pope, of Elizabeth, N. J. Eighteen thousand shares of the capital, at $50 per share, subscribed for by George Westinghouse, Jr., are paid in full, and are to be issued to him as full paid capital stock in consideration of the conveyance by him to the corporation of certain letters patent securing inventions relating to electricity, of the services of William Stanley, Jr., for two years from January 1, 1886, in experimenting in the field of electrical engineering with all the inventions made therein, and of certain contracts with Fairbanks, Morse & Co., of Chicago, and with Westinghouse, Church, Kerr & Co., of New York, for the sale of appliances to be made by this company. Attached to the application is a list of the patents conveyed to the corporation by Westinghouse. They are all inventions of Stanley, and include the electric lamp, air pumps, secondary battery, thermal cut-out, apparatus for charging and discharging secondary batteries, armature for dynamo-electric machines, filament for incandescent lamps, induction coil, multiple incandescent electric lamps, carbon for incandescent lamps, socket for incandescent lamps, electric regulator and holder for incandescent lamps. There are also pending before the Commissioners of Patents, to be part of the plant, applications for patents for a system of electric lighting, armature for dynamo-electric machines, mercury pumps, induction coil, electric alarm indicator, attachment for dynamo-electric switch or circuit controller, and others of minor importance. The company will manufacture machinery and appliances for the generation, transmission and utilization of electricity. Operations will be commenced at once.

WHAT THE PAN ELECTRIC PROPOSED DOING.

Manager Brown of the Baltimore and Ohio office at Wilmington, Del., has received the following letter, which explains itself:

WASHINGTON, D. C., Dec. 7, 1885.

Dear Sir: Observing a statement that the court had refused to grant a mandamus to compel the telephone company in your city to supply your office with a telephone, it occurred to me that it would be a good field in which to organize a company to furnish telephone service at less than half the rates charged now. If one or two of your enterprising citizens would take the matter in hand and organize a company with a capital say of $200,000, we would enter into a contract with such company to allow the use of our patents for one-fourth of the capital stock of the company without any royalty or further charge. Such a company could erect and organize an exchange of 800 instruments at a total cost of not over $12,000, which at $30 per annum rental would yield $9,000 per annum, besides, doubtless, you could establish numerous private lines between your city and other points in Delaware, which would pay you well. The cost of the instrument complete would not be over $11. We have a similar company in operation in Maryland, which has an exchange of several thousand instruments in Baltimore. We have also many private lines in Virginia, West Virginia and the District of Columbia. Our instrument is acknowledged to be in every respect superior to the Bell telephone. It would be well for you to consider this matter and take advantage of this opportunity. I would like to correspond with you on the subject.

Yours, truly,

THOS. H. GARDNER, Secretary W. T. C.

ELECTRICAL POWER TRANSMISSION.

The Massachusetts Electric Power Co., using the Daft system with its central plant at 201 Congress street, Boston, makes a business of supplying motors with power, for which it charges $150 per horse-power yearly, running 10 hours daily. A deposit of $100 per horse-power is also required to be returned at the expiration of the contract. This is to cover the cost of placing the machinery and running wires.

SUBMARINE CABLES.

For the purpose of securing certain bonds or debentures of the company, aggregating £600,000, or $3,000,000, the Commercial Cable Co. has executed a trust deed of the franchises, rights and cables to Ernest W. Siemens and Johann C. L. Loeffler, of Berlin, Germany, and Westminster, England, respectively.

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Conducted by F. L. POPE. R. W. POPE, W. P. PHILLIPS, } Associate Editors.

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NEW YORK, APRIL, 1886.

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THE INSTALLATION OF ELECTRIC LIGHT PLANTS.

THE financial success of any business depends in a great measure upon its proper establishment at the outset. This is of the more importance where expensive machinery is required, not only by reason of its prime cost, but because it is essential that it should be perfectly adapted to the particular service or location where it is to be utilized. Excellent judgment, and scientific experience must be exercised to intelligently draw the line between true and false economy.

In the early days of electric lighting a vast amount of capital was wasted by the purchase of appliances so illy adapted to the service, that it was ultimately found more profitable to sell them for junk than to continue their use. There might possibly have been an excuse for blunders of this character at that time, but such is by no means the case at present.

No saying is more true than that which tells us that modern progress is founded upon accumulated experience. Every step we make in the establishment of an industry from which a profit is expected to be derived, should be based as far as possible upon a thorough knowledge of what has been done before in the same line. If it is an entirely new field there is of course a legitimate excuse for experimenting. It is no longer right, however, that beginners should serve their apprenticeship at the expense of the service with which they are connected.

Few men would undertake the erection of a building of any pretensions without engaging the services of a competent architect, and a wise owner would moreover, endeavor to secure a professional adviser who was independent of entangling alliances with master painters, and plumbers who might levy tribute upon the proprietor unless he was unusually sagacious. Unless quality of work can be absolutely assured, the " lowest bidder " should in all cases be looked upon with suspicion. It appears to us that it is already time that both the mechanical and electrical elements of an electric lighting plant should receive more careful attention than has hitherto been the case at the hands of those who are thoroughly qualified to arrange them scientifically, which in this as in most cases means economy. We are aware that there is a wide-spread prejudice among a certain class against "book learning," but none the less it is the recognized foundation of every profession, and is nothing more than the recorded experience of others who have gone over similar ground, and have either for pleasure or profit presented to us the facts of their researches. The greater proportion of the scientific literature of the day is deduced from practical work. It is by no means theoretical to the extent that is popularly supposed. It is the proper blending of the theoretical with the practical that must lead to the best results, and in order to secure profits no detail bearing upon the efficiency or economy of a station should be neglected.

There are many lighting plants running at a loss or at least without profit to-day, which with proper management would be earning handsome dividends, while many others are struggling along under the burden of an originally poor investment in machinery which was finally discarded and replaced at a considerable loss of money and reputation for good service.

A UNIVERSAL WIRE GAUGE.

WHILE the action of the National Telephone Exchange Association at its September meeting in approving the new English standard gauge was not in itself a matter of great importance, it was a step in advance, as being in the direction of a standard international system of measurements. It is all the more praiseworthy for the reason that

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there already exists a generally recognized and satisfactory American gauge, introduced by Brown and Sharpe some twenty years ago. A deserved tribute was rendered to the pertinacity of our English friends in standing by their cherished institutions, when it was argued that as they would never adopt our gauge, the next best thing remaining was for us to adopt theirs.

There was a strong sentiment in favor of the abolition of numbered gauges, and the general adoption of actual measurement in decimal parts of an inch, a practice which has already been successfully adopted by manufacturers, and carried out to such an extent in some cases, that numbered sizes are no longer recognized, the diameter in thousandths of an inch having become as familiar as the former system of arbitrary numbers. It is also a fact that wire is now drawn to a smaller diameter than is recognized by the new English gauge, and it is also probable that the extreme degree of exactness which is now required in many branches of electrical instrument manufacture will lead to the still more general use of the micrometer gauge for the very reason that it cannot be misunderstood.

The action of the telephone association has now been endorsed by the National Electric Light Association, and as it is understood that the different telegraph companies are willing to acquiesce in the movement, it necessarily follows that the leading purchasers of wire having agreed to the change, the manufacturers and dealers, in order to comply with the requirements of their customers, will soon do their part toward bringing the gauge into practical use.

It is certainly creditable to the liberal spirit of these gentlemen, that as a matter of business they laid aside all national prejudice, and at least acted on the supposition that they were doing their part toward the abolition of what had become an unnecessary evil. Nothing is more vexatious in the transaction of business than such misunderstandings as are likely to arise from causes of this nature, and a universal standard is therefore to be commended, not because it is perfect, nor because it is English, but for the reason that there is a hope of its future general recognition.

NEW YORK AND BROOKLYN SUBTERRANEAN PROGRESS.

Whatever the character of a public work undertaken in the city of New York, it is the general supposition that there is a "job" in it somewhere, and to such an extent has suspicion been aroused regarding the work of the Commission on Electrical Subways, that its investigations bid fair to be of no avail. This is to be regretted, for the whole country has been looking to the decision of this commission as a precedent for future operations of this character. It is believed that all the possible obstacles to subterranean electrical work, are to be met with in the streets of New York, including two which are the most generally dreaded,—steam heating and water-gas systems. How many more will be developed as the work progresses, and time lapses, experience only can determine.

A different state of affairs exists in Brooklyn, where the telephone system is by far the most important electrical interest; whatever suits the telephone company is at least permitted if not endorsed by the commissioners. Of course the people have no reason to complain providing the wires are buried, for even according to the worst plan which could reasonably be looked upon as a candidate for adoption it is doubtful if the streets would be opened as frequently as they now are by the other underground tenants. The New York and New Jersey Telephone Company has already placed some of its cables in troughs of creosoted wood, and it has now made contracts for a considerable amount of conduit, part to be of the Dorsett asphaltum concrete which is extensively used in Chicago, and part to be of the Richardson "carbonized stone." Samples of the latter have been submitted to the different commissions and electrical companies of both cities, but we believe it has not as yet been practically tested for this purpose. This work will doubtless be completed before anything can be done under the authority of the New York commission as the vast number of wires to be accommodated, renders it necessary that a careful survey of the territory be made, in order that once begun the construction may proceed with a thorough understanding as to the requirements.

It is a satisfaction to know that a decision has been reached in Brooklyn, which will at least afford an opportunity of making a practical test of underground telephone wires in connection with an extensive exchange system in this vicinity.

WESTERN UNION FINANCES.

When the Western Union stockholder applies for his next quarterly dividend, and the cashier blandly asks him what he will have, he is expected to respond with that familiar phrase, "I'll take a little more of the same." The owners of these shares, which have been looked upon as a fairly good investment, will be awarded as their portion of the earnings the privilege of possessing more of them when the necessary authority is obtained for an increase of the capital stock.

There is a strong probability that the financier who suggested this ingenious scheme of a scrip dividend payable in embryotic stock, was once a small boy and the owner of a dog. With that innate prejudice against certain members of the animal kingdom, which is peculiar to many elderly persons, his mother instructed him to "get rid of that dog." When he announced one evening that he had disposed of "Tige," the old lady naturally inquired what he had done with him. He replied that he had traded him off for two pups. It is not strange that this enterprising boy became in due time a great capitalist.

It has been semi-officially announced as a reason for the adoption of the new financial policy, that the dividend was declared in scrip, because the company had more scrip than money. Having not as yet received our regular instalment of this first dividend, we are unable to determine its exact character, but it appears that the distribution of a printed circulating medium was entered upon some time ago as a matter of business in connection with one of the auxiliary companies of the Western Union. The particulars of this scheme may be learned from a perusal of the following circular:

"Executive Offices, Western Union Telegraph Co., New York.

Managers of Western Union offices:

Under an arrangement between the Western Union Tele-

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graph Company and the American District Telegraph Company (of New York), a package of Rough on Rats circulars has been sent you by mail for distribution, in the following manner: One circular to be put inside of each dwelling, tenement, shop, store, office, saloon, hotel and factory. One may be handed to adult persons, on the streets, as messengers pass from house to house. In factories or stores, where several persons congregate, one may be given to each person. After a thorough distribution, as above, if any circulars remain, they may be delivered among the druggists or medicine dealers in your place.

If possible and in your judgment advisable, use the regular force of messengers after business hours, distributing the circulars, at as small a cost as possible. If necessary, additional help may be employed for this purpose. If you think best to have the work done by some other means than our own messenger force, you should get it done at as reasonable a cost as possible. The usual charge of bill posters for like services is $1.00 per M. circulars.

A voucher covering the expenses of distribution, and for transportation charges, if any, will be rendered with your Western Union monthly account (miscellaneous column), to be charged to the American District Telegraph Company through the Auditor's office in New York.

Yours truly,
THOS. T. ECKERT,
Vice-President and General Manager."

The shareholders of the company should be encouraged by this exhibition of industry and economy which points to future possibilities in connection with the administration of great telegraph companies, that as yet have scarcely been dreamed of. The utilization of the waste of a great city is a problem which is assuming attention, as the social organization becomes more highly developed. The time now wasted by district messenger boys in front of show-windows, if intelligently directed toward prodding the ash-cans deposited along the curbstones, might result in a sufficient accumulation of coal to supply fuel to the various offices of the company. The residence portions of the city would add still more to the receipts of the company by supplying large quantities of bones. This might necessitate the organization of an ossiferous department, which could very appropriately be assigned to the charge of some of the fossils for whom there would be no other channel of usefulness in the active or industrial field which such a policy suggests. The property of the company at the foot of 55th street, North river, appears to be admirably adapted for such a purpose. In times of adversity we must stifle our pride, get up very early in the morning, take off our coats, and act upon the time-honored maxim that perseverance, industry and economy lead to wealth. Just as the old canal companies when they found their future prosperity jeopardized by competing railroads, changed their methods to conform with new conditions, so our telegraph companies if their legitimate business must be conducted at a loss, should endeavor to utilize their administrative machinery in more remunerative fields.

ARTIFICIAL ILLUMINATION.

Now that electric lighting has settled down to its proper position as a legitimate industry, there are occasional intimations, that the gas companies should adopt it as a branch of their business, which is that of artificial illumination. Whatever might have been the obstacle to such a policy at the outset, when the advocates of electric lighting threatened the gas interests with immediate downfall, there is no existing reason excepting lack of money, which now prevents their engaging in it, if they so desire. As gas companies have not gained much public sympathy, by reason of their poverty, it is more probable that the profits from electric lighting are insufficient to allure them away from their first love. So long as "fifty-cent" gas, can be sold for two dollars or more per thousand, such a business is a good thing to stick to. The gas companies have, however, been notoriously lacking in enterprise, and apparently made no effort either to improve their product or reduce its price, until compelled to do so. It is not always a wise policy to exact as high a tariff as the traffic will bear. It is natural for people to prefer plenty of light, and if it can be obtained at a reasonable price, they will have it. A rate fixed at a point which discourages consumption, may be so high as to restrict the demand and for that reason be unprofitable. On the other hand an extreme may be reached in cheapness, which will afford no profit however much may be sold. To fix upon the exact point which will lead to the highest profit, is the object of every business manager. It is quite evident that the class of lighting principally undertaken by the electric companies, has not been detrimental to the gas interests. On the contrary, it has been proved that the introduction of arc-lighting has led to an increased consumption of gas. This will not always be the case. The growth of incandescent lighting will soon encroach upon the domain of gas, which must eventually be confined to fuel purposes, and its proper share of the business of artificial illumination.

A DOUBTFUL RECOMMENDATION.

THE deliberations of the recent Electric Light Convention, held in Baltimore, were conducted in a room brilliantly illuminated by fifty-cent water-gas.—*The Progressive Age* (Water-gas journal).

THERE was but a single objectionable feature in connection with the Baltimore electric light meeting, and the above paragraph gives a sufficient reason for alluding to it. The hall required artificial illumination, owing partly to the cloudy weather which prevailed during the entire session. Open complaints were made upon the floor regarding the impurity of the air, and it was certainly worse than anything of the kind we had ever experienced. The brilliancy of the illumination was not so vivid as the imagination of the writer of the above, who obviously refers to it as a victory for fifty-cent water-gas. In order to produce sufficient light for the satisfactory transaction of business, it was necessary to light so many jets, that it is probable that a much larger proportion of the air was vitiated by the burning gas than by the audience, which at no time exceeded one hundred persons. We are yet in the dark as regards the cost of this illuminant. It was certainly dear at any price. If sold to customers at fifty cents per thousand feet, it should be used only for driving a gas engine with which to produce an incandescent electric light. If fifty cents is the cost of it to the company, we should be pleased to learn the price at which it is sold to the Carrollton hotel for instance. It is not the intention of this journal to question the methods practised by people outside of the electrical field, but in this case it appears to be desirable that the exact facts should be stated regarding the virtues of fifty-cent water-gas.

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ARTICLES.

ON TELEPHONY, AND THE OPERATION AND FUNCTIONS OF THE INDUCTION COIL IN TRANSMITTERS.

BY THOMAS D. LOCKWOOD.

On March 4th, 1876, apropos of a description of the simultaneous transmission of several different messages over one wire, achieved by Mr. Elisha Gray's harmonic telegraph apparatus—the *Scientific American* published an article by Prof. P. H. Vander Weyde, entitled "The Invention of the Telephone," which article illustrated and described the Reis telephone.

The distinction between this instrument and the ordinary telegraph, and the advance in the art which the former represented, is graphically pointed out. After describing the operation and capabilities of the instrument, Prof. Vander Weyde goes on to say "*It is clear that in this way, not only the rhythm of music can be transmitted* (*and this can be done by the ordinary telegraph*), *but the very tones, as well as the relative durations, and the rests between them, can thus be sent, making a full and complete melody.*" At this time many educational institutions throughout the world, possessed Reis telephones. But there was no *speaking* telephone. Those of us, whose memories are still unimpaired by age or interest, will have no difficulty in recollecting that if we wished to send a message from one part of a city to another, we were necessitated to use the telegraph ; or to trust ourselves to the tender mercies of the district messenger.

While the energy, enthusiasm, and optimism of the "promoter" and "organizer" were as vital and potent in 1875, as they are in 1886, none were found sufficiently hopeful to raise, or to attempt to raise a company for the exploitation of the Reis telephone as a means of internal communication. The article of Prof. Vander Weyde, was the last publication on the Reis telephone, prior to the issuance of the Bell telephone patent.

Only three days after the publication of Vander Weyde's article, that is, on March 7, 1876, a United States patent was issued to Alexander Graham Bell, No. 174,465, entitled "Improvement in Telegraphy," which enunciated the principle by which the electrical transmission of speech was made possible. This patent showed that the same principle might be applied to other purposes, as well as to transmitting speech, and there are accordingly drawings illustrating these applications ; but the speaking telephone is shown in figure 7 of the drawing, which is reproduced below.

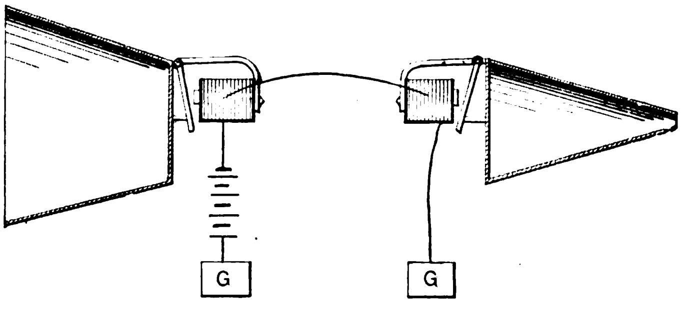

FIGURE 1.* (Figure 7 of Bell's patent of 1876.)

All the essential elements of a speaking telephone are embodied in this drawing, and in the description which relates to it ; and the subject-matter is covered by the celebrated and much abused fifth claim.

"The method of, and apparatus for transmitting vocal or other sounds telegraphically, as herein described, by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sounds, substantially as set forth."

This patent has perhaps sustained more criticism than any ever issued by the United States patent office.

We hear it gravely stated for example, that it is entitled an "Improvement in Telegraphy" and therefore it *cannot* be for telephony.

But it has never been denied that Mr. Bell's *second* patent is for a telephone ; although the said second patent, is likewise entitled an "Improvement in Telegraphy."

A consultation with common sense will tell us that telegraphy had grown to be a customary, though in some cases an inappropriate generic term, applied to all kinds of electrical communication ; and that it is just as inappropriate when applied to the Morse sounder, or the indicating dial and pointer, or the English needle system, as it is when applied to the talking telephone ; since in neither of the above systems is there any *writing* from a distance.

Then we hear that Bell did not intend to describe the transmission of articulate speech, or he would not have used the expression "vocal or other sounds." This is almost too trivial for consideration, since it is obvious that the expression used, is as comprehensive as it can well be ; but it is interesting to note that some of the corporations organized in opposition to the Bell telephone, state in their charters that their object is the electrical transmission of vocal sounds.

We are also informed that the apparatus shown in figure 7 of the patent is inoperative ; that it will not work. But it is now a matter of history that this statement is untrue ; that instruments made in accordance with the drawing, and description, *do* work perfectly ; and as Judge Lowell said, "in the mode pointed out by the specification."

It is not necessary, however, for the purpose of this article, to rehearse all of the attacks which have been made upon the patent, or the way in which they have been parried. The main truth stands. The patented "*telegraphy*" of 1876, is the foundation of, and is identical with the patented "*telephony*" of 1886.

The line ; the transmitting membrane to receive the sound vibrations of the original voice ; the receiving membrane to reproduce them ; and the means and method of linking the two diaphragms together, so that one will copy the other, are all embodied in the patent of March 7, 1876.

But it was easy to see that the principle once elucidated, could readily be utilized, and that the apparatus shown in the patent were susceptible of a good deal of mechanical improvement. It was not long before this improvement took shape. The membrane diaphragm carrying a separate armature was dispensed with, and the two elements were combined by the use of an iron diaphragm. The electro-magnetic coil was shortened, and placed round the core near its end, so as to surround the pole only, instead of surrounding the entire length of core, it having been found that so formed and placed, it more easily influenced the magnetism of the core. A permanent magnet was employed in place of the electro-magnet and line battery which had heretofore been used, and was preferably fitted with soft iron pole pieces. A flattened air condensing chamber was also provided in front of the diaphragm having an orifice at its centre for a mouth or ear piece.

At this stage, the speaking telephone had developed into a practical and commercially successful communicator.

In the cut, figure 2, a circuit connecting several such telephones is shown.

A considerable number of such telephones or telephone stations, may, as indicated in the cut, be placed upon the same circuit, and words spoken into any one of them, will be copied and reproduced by all of the others, so that a listener at any station can hear what is said.

It is now time to recall what was a perfectly familiar fact to the early patrons of the telephone ; the fact that magneto telephones, such as those shown in the figure, have a dual function.

In addition to their capacity for acting as receivers, in the way they are universally employed at the present time,

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they are highly efficient transmitters; and it is undeniably one of the most wonderful and admirable features of the magneto telephone, that it can be so used :—that an electric circuit may be fitted at each station, with instruments identical in every detail, which may be utilized indifferently either to send or to receive the message; and although the late Clerk Maxwell would tell us that "an animate organism with both ends alike is a pretty low order in the scale of creation," we have good reason, I think, to regard this instance as exceptional, and to admire the conception and realization of the electrical transmission and reproduction of speech upon this heretofore even unimagined plan.

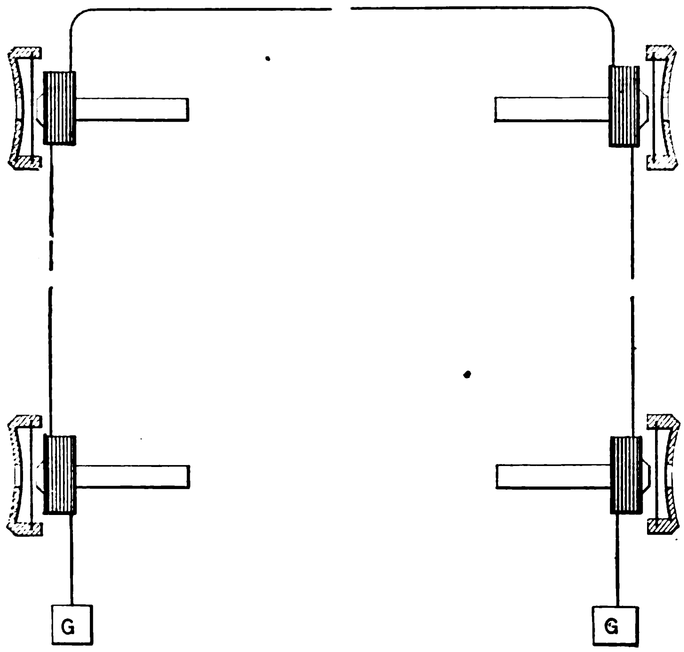

FIGURE 2.

At the present time it is probable that of upwards of two hundred thousand users of the telephone in the United States, a comparatively small number know that the receiving telephone can be used as a transmitter, although not until the fall of 1877 was there any other instrument available for the purpose.

The magneto telephone as shown in figure 2, and in fact as at present constructed (for there has been no special change made in it), comprises three essential elements :— the magnet, the coil or helix which forms a part of the electric circuit, and the diaphragm. The enclosing case, screw terminals, and mouth or ear piece are all useful, but are not essential.

As one of the curiosities of telephony it is worthy of note, that although it is true, as I have stated, that the magnet, coil and diaphragm, are essential; it is experimentally possible to construct and operate a magneto receiving telephone in which one or more of these elements are dispensed with, but which is quite capable of reproducing words.

Thus, M. Clement Ader has made telephones which dispense with the vibrating plate; others, consisting solely of a helix of wire in an electric circuit; and others consisting only of an iron rod fixed by one end to a sounding board, and having the circuit wires connected with its ends. Such instruments are, however, nothing more than curiosities (specimens of electrical gymnastics as Robert Sabine hath it); and for the electrical reproduction of spoken words, uttered at a distance, in a practically and commercially successful way, I do not, I think, overstep the bounds of strict veracity when I maintain the essentiality of the three elements aforesaid.

Now, as to the magnet of the magneto telephone: as at present uniformly made, the magnet is a permanent one, made usually of several steel bars, provided with a soft iron pole piece, as depicted in figure 3.

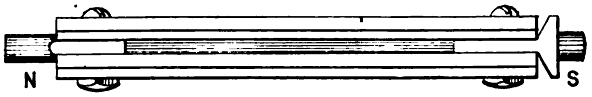

FIGURE 3.

In this form, the soft iron core is inductively maintained in a state of magnetic polarization by its attachment to the steel magnet; for ready reference I will throughout this article call this arrangement plan A. But the pristine arrangement was, as indicated in figure 1, to provide an electro-magnet of the ordinary type with a soft iron core, which was rendered magnetic by a main battery included directly in the main or line circuit. This arrangement I will designate as plan B.

At an early epoch in the history of telephony it was seen that the magnetization of the core by means of the permanent magnet was fully as effectual as when it was accomplished by the line battery; and being a much more convenient and economical plan, was adopted almost exclusively. There is, however, still a third plan which is delineated in the figure below.

This is to use an electro-magnetic helix, B, which is permanently vitalized by the current of a local battery, L, and to provide a separate main line electro-magnetic coil, C, mounted in close proximity to the diaphragm. One soft iron core, D, may serve for both coils. That is, the core D may by the local circuit coil B, be maintained in a magnetic state, which is varied in intensity by the currents arriving from the distant station through the coil C, which surrounds the end of the core; or by the movements of the diaphragm.

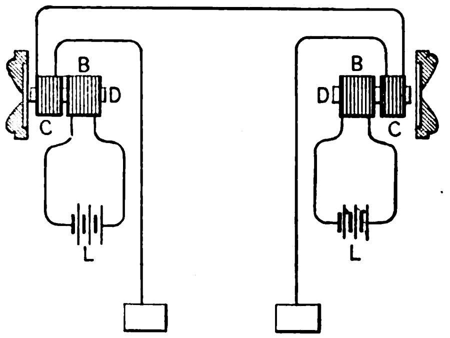

FIGURE 4.

Or, the two helices may each have its own separate core and these may be either in absolute contact with one another at the proposed ends, or separated only by an infinitesimal air space, or by a thin non-magnetic partition such as brass or mica. In the two latter cases, the core E, is inductively magnetized by the contact or proximity of the electro-magnetic core D. It is of course possible by the utilization of this plan, to effect a much higher degree of magnetic saturation in the core than by either of the former plans; and it would seem, therefore, that in some cases, where convenience, portability and economy need not be regarded, that the efficiency of the instrument might be increased by its adoption.

It will not do however, to hope too much from it, as the success of the instrument depends not upon the original intensity of magnetization, but upon the extent of variation we can produce in that magnetic state.

This arrangement may be called plan C. Attention is especially called to this plan as it is a pointer in the

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direction which I shall shortly consider, and towards the line of thought to be elaborated.

To fully appreciate the magneto telephone we have to regard it in its twofold capacity. Its operation as a transmitter, while analogous to, is quite distinct from its operation in the character of a receiver.

We will consider first, the working of the apparatus when used to transmit.

On speaking before the mouthpiece of a telephone, the plate vibrates ; alternately approaching and receding from the pole of the magnet. By its movements, it modifies the distribution of the magnetic lines of force radiating from the magnet, so that the intensity of such of those lines which direct themselves through the surrounding coils, is alternately magnified and diminished ; and the result is, of necessity, that induced pulsations of electricity are set up in the coil, which pulsations propagate themselves over the circuit of which the helix forms a part, to the distant station, there to affect the receiving instrument which transforms them once more, in due course, into sonorous vibrations. The telephone, so used is a real generator of electricity, which not only produces the currents, but which regulates their strength and direction simultaneously with their production, and which moreover regulates them in such an effectual manner as to cause them to vary precisely in correspondence with the variations in pitch and quality of the original sound.

The strength of the electric impulses so developed, depends upon the amplitude or extent of the to and fro movement of the diaphragm ; while the direction of the electricity depends upon the direction of the diaphragm's movement. If the diaphragm at a given moment is vibrating *towards* the magnet, the current generated is in one direction ; if it is vibrating *from* the diaphragm, a current of opposite direction is produced.

In two of the plans which I have described, of effecting the initial magnetization, there is no electric current on the line, until the diaphragm actually begins to vibrate. Every part of the electrical excitement is, therefore, due to such movement ; and the electrical condition of the circuit, may at any given moment consist of an excitement by a plus current, a zero condition, or an excitement by a minus current. But when the original plan is employed there is *an initial* current always on the line, and this being due to a battery connected directly in the line circuit, is of course much stronger than any current which the telephone itself can develop. The telephone currents are in this case, consequently, superimposed upon the original current, which is either weakened or strengthened by them, the electrical state of the line never reaching an absolute zero. It is the conditions of the two plans in which the line battery is dispensed with, and the fact that in the transition from a current of positive direction, to a current of negative direction, and *vice versa*, a moment when there is a total absence of electrical excitement is unavoidable, that has given rise to one of the most persistent arguments against the theories adopted by the advocates of Mr. Bell. The difficulty is but an imaginary one. Those who set it up, continue to argue as if Mr. Bell had claimed to have discovered or invented what he calls an *undulatory current, per se* ; or, as though he had claimed that the successful transmission of speech depended simply upon the employment of such a current, without limitation as to the form of the undulations.

Mr. Bell's claim is the one which, now that his patent is ten years old, cannot be stated more succinctly or graphically than it is stated therein :—viz., that success in the operation depends upon producing electrical undulations in the connecting wire, similar in form to the air undulations of the original sounds, which are to be reproduced.

This being once thoroughly impressed upon the mind of the student, it is easy to see that if the zero point of the electrical excitement of the line occurs at a regular point of these electrical undulations, it virtually becomes a part of them ; and is thus in entire consonance with the method as above stated.

This is ordinarily illustrated by the curve, figure 5.

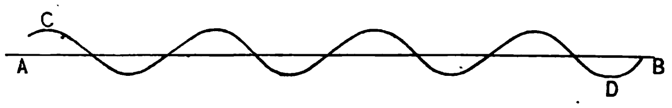

FIGURE 5.

A horizontal line A B, is there shown, and a sinusoidal curve, C D, passing alternately above and below it.

The line may represent the zero of current, the curves above the line indicate positive electrical impulses, and those below the line, negative electrical impulses. Now, although the zero points, E, are continually and successively reached, the approach to them, and recession from them, it will be observed, are equally as gradual and regular as the approach to, and recession from, any other point in the curve. In fact the undulation is just as much an undulation at the zero point as at any other point in the curve, or in the electrical condition of the line. It is not usual to insist that a vibrating pendulum stops, because when reaching the end of its swing in one direction, there is unavoidably a dead point, before it can begin its swing in the reverse direction.

Nor do we hold that there is a practical cessation of motion in the piston of a locomotive, because its motion is now in one direction, and now in another, and because the moment of reversal implies a moment of quiescence. Much less then is the zero of the telephone current, to be understood as a moment when the electrical changes totally cease.

(*To be continued.*)

ON THE ELECTRICAL PROPERTIES OF GERMAN SILVER.

BY GEORGE B. PRESCOTT, JR.

It is hardly necessary to state that the alloy of copper, nickel and zinc, commonly known as german silver, is extensively employed in the electrical arts ; nor is it needful to inform those who have had occasion to use very much of it, that the commercial article varies in quality to a most inconvenient extent. Of all known alloys of the more common metals, german silver has the highest specific resistance, and its resistance is least affected by variations of temperature ; these properties which are, furthermore, fairly permanent, make it invaluable for rheostats, resistance coils, and wherever high resistance is required, whilst in wire for standards of resistance they are essential. For electrical purposes, at least, uniformity of quality is also demanded, for on the proportions of the constituent metals in the alloy, depends its electrical properties. Whatever the proportions of the original alloy called german silver may have been, to-day the name stands for any mixture of copper, nickel and zinc that it may suit the maker's fancy to adopt ; hence the lack of uniformity in the german silver wire purchased, not only from different dealers, but from the same dealers at different times.

In looking over the *Philosophical Transactions*, and other journals, while engaged in an attempt to ascertain the quality of the german silver alloys employed by Matthiessen, Siemens, Thomson, Von Bose, Vogt, Hockin, and other experimenters in the early days of electrical measurement I was astonished to find that in not a single instance, in the published accounts of their work, had they deemed it necessary to state the proportions of the german silver which they tested, although they were careful to give the exact quantities of the constituents of every other alloy. Even Dr. Matthiessen in his report to the B. A. Committee on Electrical Standards, in which he gives the specific resistance and temperature coefficient of german silver, describes it

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only as "the alloy usually used for resistance coils." The later electrical text books are scarcely more explicit on this subject: Jenkin, as might be expected, merely gives Matthiessen's values for resistance and temperature of "the alloy usually used for resistance coils," but does not state what the alloy is; Sprague copies the same figures, but adds that the resistance of the alloy varies with the proportion of nickel; Hospitalier copies the table from the B. A. report without remark, but in another portion of his pocket-book, where one would hardly think of looking for such information, he quotes Sprague's statement; and in still another place gives the proportions of the common alloy as being (according to Regnault), copper 50, zinc 30, nickel 20. Munro and Jamieson, in their new pocket book of electrical formulæ, give the B. A. table with the usual explanation, and on another page state that german silver weighs about 530 pounds per cubic foot, has a specific gravity of 8.5, and consists of four parts copper, and two parts nickel, and one part of zinc. On the opposite page they give a table, by Elliott Bros., of the resistance of various sizes of german silver wire, and leave it for the reader to discover that its basis is something quite different from that of the B. A. table. Kempe in an article on electric lighting, published in the London *Electrical Review*, mentions the difference found in german silver alloys, and then gives an approximate formula for the resistance of german silver wire. It is so very approximate that it falls short of the B. A. value on which it is evidently based, but it at least has the merit of not assuming a standard temperature. American authors have not yet attacked the subject, but American manufacturers freely copy in their trade catalogues, as representing the properties of their particular wire, such of the above figures as they happen to stumble on.

In the following table are given the results of tests of samples of german silver wire, bought in the open market. As resistance wire it is the best that has come into my hands. It is vastly superior to the Matthiessen or B. A. standard wire, and has a higher specific resistance than that supplied by Elliott Bros. Although, in fact, much better than the wire ordinarily sold, yet it can always be duplicated on demand. Matthiessen's temperature correction for german silver is .024 per cent. per degree Fahrenheit, but as this figure is obviously too great for wire of higher

COMMERCIAL GERMAN SILVER WIRE.

Wire.		Diam. Mils.	Weight per foot in Grains.	Resistance per foot.	Tem. in deg. F.	Mile-Ohm. lbs.
Maker.	Lot.					
Matthiessen B. A. Report...........	... .	.142	1.000	2.68ω	60°	10672
Elliott Bros........		1.	.02023	150.ω	60	12088
Am. Elec. Works..	No. 1	8.75	1.581	2.3789	81	14504
"	"	6.65	.8874	4.197	81	14495
"	"	8.75	1.561	2.3898	86	14857
"	"	6.65	.8928	4.2005	86	14896
"	No. 2	8.5	1.457	2.6137	78	15165
"	"	6.4	.8241	4.6289	78	15192
Coe Brass Co......	.....	44.5	41.251	1.0035	83	16590
"	......	20.5	8.708	4.6857	83	16353
Holmes, Booth &	......	6.2	.9332	5.2174	86	16514
Haydens.........	......	8.1	1.363	3.2861	86	17834

specific resistance, I have preferred not to correct to a standard temperature the figures given in this table, more especially as I now feel uncertain as to the proper correction to be applied to the standard coils. As a unit of comparison, I have preferred for convenience, to adopt the weight in pounds, of one mile of wire having one ohm resistance. This unit, known as the weight per mile-ohm, if divided by the weight per mile, in pounds, of any other similar wire, gives as a quotient the resistance per mile of that wire. The specific resistance of the alloy of which any wire is composed, is, therefore, proportional to its weight per mile-ohm. The specifications of the United States Electric Lighting Co., require that all german silver wire supplied to it shall have a mile-ohm of at least 15,000 pounds. For the purpose of comparison it may be stated that the Western Union Telegraph Co., which uses high conductivity iron wire, specifies that its mile-ohm shall be under 4,800 pounds at 68° F.; and that the weight per mile-ohm of pure copper at 60° F., is 871 pounds.

In May last, a paper by Mr. J. T. Bottomley "On the Electric Resistance of a New Alloy named Platinoid" was read before the London Royal Society. This alloy is the invention of Mr. F. W. Martino, and is described as being practically german silver with the addition of one or two per cent. of metallic tungsten. Mr. Bottomley claims that the specific resistance of platinoid is one and a half times that of german silver, and that its mean temperature correction is just one-half as much. On referring to Mr. Bottomley's paper it is discovered that by german silver he means that quality from which Matthiessen derived his resistance and temperature coefficient figures; but he gives no information as to the quality of the alloy to which one or two per cent. of tungsten was added, although he mentions that the resistance of german silver is different in different specimens; perhaps he did not wish to trouble the distinguished members of the Royal Society with details. However, the alleged discovery was of such importance that Mr. Edward Weston undertook to investigate it thoroughly, and the results of his investigation are highly interesting. These results he proposes to prepare for publication some time in the near future, but in the meanwhile I am permitted to say that, generally speaking, he found the addition of tungsten not to have the slightest effect on the electrical properties of german silver, even when present to the extent of five per cent. On the other hand he found its resistance to vary almost directly with the quantity of nickel, and that *the effect of changes in temperature on the resistance of the alloy varies inversely as the quantity of nickel;* in other words the greater the percentage of nickel the smaller the temperature correction. The effect of zinc in the alloy appeared to be that of simple dilution: it makes the alloy ductile however, and its presence is useful for mechanical reasons.

The following table gives the weight per mile-ohm of various german silver alloys, as determined by Mr. Weston. The proportions of the metals are those adopted in mixing, and no temperature corrections are given, as experiments in this direction are still incomplete. The actual analysis of the different alloys after being remelted and drawn, and their respective temperature corrections, will be given in Mr. Weston's paper. If properly annealed it does not appear that drawing german silver into wire alters its electrical properties, but during the melting process more or less of the zinc is oxidized, and the proportions of the finished alloy, are therefore, somewhat different from those of the original mixture.

GERMAN SILVER ALLOYS.—Experiments by Edward Weston.
Temperature about 75° F.

Alloy No.	Parts.			Weight per Mile-Ohm lbs.	Percentage of Nickel.	Remarks.
	Copper.	Nickel.	Zinc.			
64	100	20	50	11572	12	
83	100	30	50	14599	17	
55	100	33	50	15325	18	Remelted.
62	100	33	50	15448	18	"
60	100	33	50	15626	18	Redrawn.
63	100	30	30	15599	19	
65	100	40	50	18054	21	
101	100	50	50	18172 (?)	25	New Lot Nickel.
79	100	50	50	19009	25	
92	100	50	50	19077	25	Lost weight.
90	100	50	50	19594	25	
91	100	50	50	19670	25	
77	100	50	50	20354	25	
78	100	50	50	21402	25	
..	100	78.74	52.75	24485	34	

My object in writing this article has been to give such information regarding german silver, as will enable those who have occasion to use it for electrical purposes to select the quality which is best suited for such purposes. The question is one of considerable importance from the com-

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mercial point of view, when it is considered that the users could profitably afford to pay double the price for wire with 20,000 pounds to the mile-ohm, that they have to pay for the ordinary market wire having a mile-ohm of about 10,000 pounds.

In conclusion I would suggest that manufacturers of german silver for electrical uses, specify the quality of their product by percentage of nickel in the alloy; and that dealers ascertain the quality and properties of the wire which they sell, before publishing tables of resistances.

WESTON LABORATORY,
Newark, Feb. 26th 1886.

CARRYING AND DISTRIBUTING ELECTRICAL CONDUCTORS THROUGH CITIES.

BY ELIAS E. RIES.

(Continued from page 52.)

LEAKAGE, INDUCTION, AND RETARDATION.

WE will now briefly consider the nature of the difficulties to which different classes of electrical conductors are subjected when carried through cities in the ordinary manner, and ascertain how these difficulties, which up to the present time have resisted all such attempts, can best be overcome.

These difficulties are :—

1. *Leakage.* This is a fault principally met with in overhead conductors, although underground conductors are by no means exempt from it. As generally understood, leakage is a direct escape of a portion of the current from one wire to others carried in the same cable or supported on the same poles, or from an electric wire or conductor to the earth. It is in all cases due to poor or defective insulation, enhanced in the case of overhead wires by exposure to the elements, especially to rain and moisture. The primary effect of leakage is of course to weaken the strength of electrical current flowing through the wire, and it is apparent that this will interfere with the proper working of the apparatus in circuit, especially where it is essential to keep the current at a practically uniform standard of strength. Where, however, leakage is caused through defective insulation between two or more otherwise well insulated wires, as sometimes happens when a number of individually insulated wires are grouped together in cables or conduits, or when leakage results, as it frequently does among overhead conductors, from a direct metallic contact of one wire with another (technically termed a "cross"), it necessarily augments the trouble, since the escaping current from one line will interfere to a greater or less extent with the operation of the instruments on the other wire or wires, and in the event of a direct contact will render them entirely useless until the fault is repaired. Fortunately this difficulty is but seldom met with in underground conductors, and can be easily guarded against by exercising a little care in the matter of insulation. It is well to remember, however, that no insulation is absolutely perfect, and in cables of considerable length too much care cannot be taken in securing a high degree of insulation; and this is especially true as regards conductors designed to carry currents of high tension or electromotive force.

2. *Induction.* This is the effect produced when the signals or electric impulses sent along one wire are indirectly taken up by other wires running in the same direction, and is manifested whenever two or more parallel conductors are carried in close proximity to each other for a considerable distance. For every interruption or variation in the strength of current flowing through one of these conductors, a corresponding change is momentarily induced and takes place in the current traversing the neighboring conductors, and these changes will seriously interfere with the operation of the instruments in circuit therewith. In the case of overhead wires or pole lines this effect is not felt to such an extent as in aerial or underground cables, in which the conductors are necessarily grouped closely together, and as cables are rapidly superseding individual wires wherever practicable, and it being necessary in any conduit system to economize space as far as possible consistent with proper and satisfactory service, it will be evident that this difficulty is one of no mean proportion.

As there appears to be considerable misunderstanding in the minds of various promoters of conduit systems, and others as to the nature and cause of induction and the extent to which the operation of different classes of conductors are affected thereby, this question will be treated with a little more detail, inasmuch as without a thorough knowledge of the principles involved and the employment of the proper means for preventing or obviating as far as possible the effects of dynamic induction, the construction of a successful conduit system will be impossible.

We have stated that induction is the effect produced when the signals or electric impulses sent along one wire are indirectly taken up by other wires running in the same direction. The manner in which this is rendered possible will be better understood by the following analogy. If we take two small wires, running parallel and near each other, and pass through one of them an electric current of sufficient strength to bring it to a red heat, the other wire will become perceptibly warm; and if the current flowing through the first wire be interrupted at intervals, the heat waves traversing the second wire will be interrupted in a corresponding manner. If now we suppose that the cooling and heating of both wires takes place instantaneously upon the cessation and commencement of each impulse of the current, we have a pretty fair illustration of the effects of induction, and can readily see that an instrument, such as a thermometer, on the second wire, will be indirectly affected by and respond to the electrical impulses or signals sent along on the first wire. Now, while this analogy will enable us to comprehend how an electric current flowing through one conductor may interfere more or less seriously with the operation of the instruments on another conductor, there are one or two slight points of difference between the real operation and the supposed case, which it may be well to mention. In the first place, the impulses due to electro-dynamic induction are not caused by variations in temperature, but by destroying the established electrical equilibrium which normally exists on and pervades to a greater or less extent all bodies in the vicinity of an electric conductor, and which occurs every time the electric current flowing through it is made or broken, its strength increased or diminished, or its direction reversed. As an example, if two conductors are placed near together and each carry an electric current of equal strength, and the current flowing through one of them be suddenly interrupted, the electrical equilibrium which previously existed in the vicinity of the two conductors will be momentarily destroyed owing to the dissipation of the charge, and the current flowing through the remaining conductor will then exert its influence in attracting the electrical equilibrium to itself as a centre, or in other words, setting up in the surrounding medium lines of force running parallel with the conductor and strongest in its immediate vicinity.

A portion of the escaping charge or excess of current which at the moment of interruption has concentrated itself around the remaining conductor will find its way to earth through this conductor until the equilibrium is readjusted, which will be almost immediately, and thus momentarily produces an increase of current which constitutes in this conductor the inductive impulse. If, however, the second conductor is not in connection with the earth the excess of current finds its way to earth through other neighboring conductors or in their absence is dissipated in the ordinary manner. When the current is again sent through the first conductor, the electrical equilibrium is

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restored to its original state, but not without again momentarily destroying the electrical balance by attracting a portion of the static charge flowing in the vicinity of the second conductor to itself, and thus causing a slight decrease in the strength of current flowing through this conductor until the balance is restored, and this momentary decrease constitutes the second inductive impulse. Thus for each make and break in the current sent through the first wire the normal strength of the current traversing the second wire is momentarily diminished and increased.

Returning now to its practical effects, we find that the extent to which induction from one conductor may affect another conductor running parallel with it depends principally upon the following :—

1. The proximity of the two conductors.
2. The length of the parallel portion of the conductors.
3. The character, and intensity or strength of the inducing or primary current.
4. The specific inductivity or inductive capacity of the insulation separating the conductors.
5. The size of the conductor in which the current is induced.

It is well known that, owing to the extreme sensitiveness of the telephone to the slightest variations in current strength this instrument is more susceptible to inductive influence than any other, and when telephone wires are carried in the form of cables this difficulty is greatly augmented, and increases with the length of cable so rapidly that it is almost impossible, without the use of some preventive of induction, to speak through a length of more than 800 feet. In telephony the effect produced by this difficulty is known as "cross talk," so called from the fact that the conversation passing over one wire can be heard, through induction alone, by listening at the telephone on another wire, and in cables exceeding the above length this cross talk becomes so confusing as to drown the direct conversation. It may be said in passing, however, that much of this difficulty is due to direct leakage between two or more wires caused by defective insulation, as before stated.

Telegraph conductors are also affected by induced currents from adjacent wires, and telegraphic signals passing along one wire can readily be perceived by listening at a carefully adjusted instrument on another wire, when the circuit of the last named instrument remains closed. In practice, however, it is found that inasmuch as most forms of telegraphic systems require a make and break current, the slight variation in current strength due to induction is not sufficient to materially interfere with their operation. When telegraph conductors are carried closely together, as they would be in cables, the effects of induction are felt to a greater extent, and in cables of considerable length would prove seriously detrimental to the operation of the instruments, unless the precaution is taken to change the relative position of the several wires with respect to each other at proper intervals throughout the length of the cable, at least once in every 3,000 feet. While this does not prevent induction from taking place, it will nevertheless break up the induced currents among the different conductors, and the inductive influence of these currents is in turn counteracted by similar currents from other wires, so that the amount of induced current traversing any particular conductor of the group will not be of sufficient strength to be appreciable.

The difficulty arising from dynamic induction is seriously augmented when different classes of conductors are carried in the same conduit, and it is this feature of the problem that requires our special attention. It is clear that if it is desired to carry telephone, telegraph and electric light conductors in one conduit structure, special provision must be made to eliminate the effects of induction.

Various devices have been employed to accomplish this object in the case of individual wires or cables, and though some of them give satisfactory results when so employed, it is evident that other means are necessary to neutralize or counteract induction in an inclusive and comprehensive conduit system such as we have under consideration.

Before describing how this difficulty may be obviated, we will briefly review the manner in which induction manifests itself between different classes of conductors.

Every electrical conductor may be said to occupy the centre of what may be termed its "inductive field." From what has previously been said it will be understood that induced currents are produced by changes in the electrical equilibrium of this field, these changes being themselves caused by interruptions or variations in the strength of the current flowing through the inducing or primary conductor. The extent of this field, or in other words, the distance from the conductor at which induction can be perceptibly felt, varies with the intensity of the current flowing through the conductor, while the degree to which the induced current will affect another conductor at a given distance from the first will depend upon the amount of variation in the current strength, or the difference of electrical potential or pressure between any two successive electrical impulses. As the tendency of the inductive charge is to flow to earth as quickly as possible, it follows that the induced current will pass over a conductor grounded at each end in preference to one having a metallic return ; and of two conductors of unequal diameter, but similar in other respects and placed at the same distance from a conductor through which an electrical impulse is sent, the larger conductor will carry off the greater portion of the induced current. It must also be remembered that an electrical current flowing along one conductor is capable of inducing a current in a neighboring conductor through which no current is flowing, or in a parallel conducting body in electrical connection with the earth.

Now it has been practically demonstrated that induction will take place, to a greater or less extent, through the best of insulating material, the relative extent to which it does take place depending merely upon the specific inductivity of the insulating medium, which, however, never reaches such a point in any known substance as to make it of practical use as a preventive of induction. As a rule, the better the insulating material employed the more pronounced is the induction between the two wires.

It will be clear, therefore, that we cannot prevent induction between electric light and telegraph conductors, or between telegraph and telephone conductors, by merely insulating the conductors of one class from those of another, but if we interpose between two or more groups of such conductors, a continuous metallic shield or partition in electrical connection with the earth, all induced currents that are not counteracted or neutralized by the individual conductors of each group are absorbed and carried off by the metallic partitions. This plan has been successfully employed for eliminating dynamic induction between individual conductors in certain forms of underground cables, but inasmuch as the electro-static capacity of the cable, or in other words, the difficulty arising from static induction, is increased thereby, it is necessary to modify this arrangement somewhat to adapt it to the requirements of an "inclusive" conduit system, and later we will explain how this may be most effectually accomplished so that the different classes of conductors can be carried in one conduit without mutual interference.

3. *Retardation.* This is one of the greatest obstacles to the satisfactory operation of underground conductors, and is probably the most difficult to overcome. This phenomenon is due to static induction between an electric conductor and the earth, and appears whenever an insulated conductor is buried in the earth or submerged under water throughout the whole or a portion of its length. When an electric current is sent through an overhead conductor, it arrives almost instantly at the distant end,

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but when sent through an underground conductor a portion of the current is held back or "retarded" by the inductive or electro-static action of the surrounding earth. As it is necessary that an electrical current or impulse, however short, must traverse its entire circuit, *and be actually engaged in doing so*, before it can make itself felt on any portion of the line, it will at once become apparent that anything that opposes the free and rapid passage of an electric current over a conductor will seriously interfere with the speed of signaling, especially on telephone and certain forms of telegraphic circuits, where the signals, or the electric impulses which produce these signals, follow each other with exceeding rapidity. When the telephone or telegraph conductors are carried underground for a considerable distance, each impulse or signal, instead of being sharp and distinct, is partly kept back, so that it overlaps and mingles with the next, and if, as before stated, the currents are extremely frequent, the result is to confuse and entirely destroy the signals.

The extent to which electro-static induction affects different conductors varies considerably. Submarine conductors are affected to a much larger extent than subterranean conductors, owing to the better and more uniform conductivity of the substance surrounding them. For the same reason, an insulated conductor buried in moist earth is affected to a larger extent than one surrounded on all sides by dry earth, and the larger or more extensive the mass of conducting matter surrounding the conductor the greater will be the retardation. The electro-static capacity of a conductor, or, in other words, the "charge" or amount of current that may be accumulated or held back upon it at one time by the inductive influence of the earth, increases in proportion to the length and thickness of the wire, and the retardation and prolongation of the signals due to static induction is more pronounced when a strong current is used than with a weak current.

Thus it will be seen that telephone conductors, although carrying a very great number of *undulatory* electric impulses in a given space of time, are not affected in their operation by static induction to such an extent as are telegraph conductors carrying a *make and break* current of *greater* strength, even though the impulses do not follow each other quite so rapidly in the latter. Moreover, as telephone conductors usually carry a much weaker current than telegraph conductors, they are generally made smaller in diameter, and their electro-static capacity is thereby proportionately reduced.

Conductors belonging to the third-class, such as those used for electric arc and incandescent lighting, for the transmission of power, etc., are not affected, as far as regards efficiency, by static induction, provided they employ a direct and comparatively steady current; and if good conductivity and insulation is insured, there is no reason why they should not be successively carried underground. Indeed, as far as arc light conductors are concerned, the electro-static action of the earth will tend to tone down and steady all the slight but sudden variations in the current strength which are almost unavoidable in this class of conductors, and thereby rid them of one of their most objectionable features.

As we have before stated, of all the technical difficulties to which underground electric conductors are subject, retardation is the most difficult to overcome, and it is just here that it will be necessary to exercise considerable judgment in devising our conduit system, so as to expose the conductors carried by it as little as possible to the influence of electro-static induction. Fortunately, in a *properly organized* conduit system for city use the underground length of any individual conductor need not be prolonged to such an extent as to render it subject to retardation, and this is well to remember. We must not, however, lose sight of the curious fact that while the electric light conductors, which are least disturbed by electro-static induction, extend but a short distance and are seldom or never called upon to go outside the city limits, the class of conductors principally affected when carried underground, viz.: the telegraph conductors, are the very ones that, as a class, extend to the greatest distance and frequently pass through a number of different cities. Therefore, while we may succeed in carrying these conductors through the conduit system of one city without materially interfering with their satisfactory operation, the problem becomes more difficult when it is necessary to carry them underground through a number of different cities without at the same time interfering with the present rapid systems of transmission employed.

(*To be continued.*)

THE SELF-INDUCTION OF AN ELECTRIC CURRENT IN RELATION TO THE NATURE AND FORM OF ITS CONDUCTOR.[1]

BY PROFESSOR D. E. HUGHES, F. R. S., PRESIDENT.

INDUCED or secondary currents in a near but independent circuit were discovered by Faraday in 1831; and the phenomenon of the self-induction of an electric current in its own wire was observed by Henry in 1832, and traced to its cause in 1834 by Faraday, who proved that on sending a current through a wire a momentary induced current in the opposite direction is evoked in its own wire; also that, on the cessation of the primary current, a second induced or "*extra-current*" is excited in the direction of the primary. The effect is greatly augmented when the wire forms a coil, as we then have in addition the reaction of superposed currents; but the effect exists to a great extent even when the wire forms but a single loop, or a straight wire with the earth forming the returning portion of the loop, as in all telegraph lines.

It has been generally supposed that the nature or the molecular condition of the metal through which the primary current passed exerted no influence upon the extra currents except that due to its resistance. I have previously pointed out[2] that for induced currents "the rapidity of discharge has no direct relation with the electrical conductivity of the metal, for copper is much slower than zinc, and they are both superior to iron." This led me to make a study of these extra currents, for which purpose I constructed a special induction bridge, in order to measure both the primary and its extra currents separately at the instant of action.

INDUCTION BRIDGE.

This instrument is a combination of a portion of my "induction balance," with a "Wheatstone bridge." The resistance of the wire is measured and balanced by the bridge; the induced or extra currents are measured and reduced to zero by an equal opposed induced current from the induction balance.

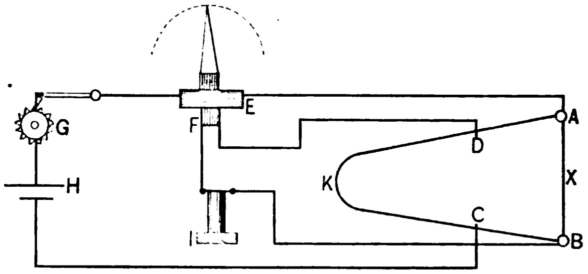

FIGURE 1.

The above diagram shows the electrical communications. The bridge consists of a single german silver wire (0.25 mm. diameter, 1 metre in length, of 4 ohms resistance)

1. Inaugural address before the Society of Telegraph Engineers and Electricians, London, Eng., January 28, 1886.

2. "Induction-Currents Balance," *Proc. Roy. Soc.*, vol. xxix., p. 56, 1879; "Molecular Electro-magnetic Induction," *Proc. Roy. Soc.*, March 7, 1881.

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running from A to K, returning to B. The wire is stretched and sustained upon two wooden arms articulated at K, by means of which the terminals A B can be more or less separated as desired. The wire to be tested, X, is joined at A and B, thus completing the closed circuit of the bridge.

The external communications are shown, A being connected to the primary coil of the sonometer E, and through it to the spring of the interruptor or rheotome G, the interrupting wheel being connected to the battery H, and thence to the bridge at C. The wire from B passes through the telephone I to the secondary coil F, returning to D.

Great care has to be taken in the construction of the bridge, so that it shall be as free as possible from induced or extra currents; and for this reason we cannot employ or introduce resistance coils. The resistance of the wire X is balanced by sliding the communications D and C. It is evident that if all the arms of this bridge are equal in resistance and inductive capacity, there will be silence on the telephone; but if A B be slightly stronger or weaker in inductive capacity, then we may be able to balance its resistance, but not its induction, as we shall then have a slight or a loud continuous sound due to the differential extra currents in the arm A B. These are compensated by the introduction in the circuit of the telephone of an equivalent but opposed induced current from the secondary coil of the sonometer F, the degree of angle through which this coil has turned to produce silence being the degree of force of the extra current. The induction sonometer[8] consists of two coils only, one of which is smaller and turns freely in the centre of the outside coil. The exterior coil being stationary, the centre coil turns upon an axle by means of a long (20 cm.) arm, or pointer, the point of which moves over a graduated arc or circle. Whenever the axis of the interior coil is perpendicular to the exterior coil no induction takes place, and we have a perfect zero; by turning the interior coil through any degree we have a current proportional to this angle, and in the direction in which it is turned. The value of the induction current for each sonometric degree was $\frac{1}{1500}$ of the primary current which passed through the wire under observation, the latter being variable at will from .001 to .250 ampère. There is also a reversing key (not shown in the diagram), in order to place the interruptor on the telephone circuit and close the battery current from H to A; the conditions then being the usual method of testing, except using the telephone in place of a galvanometer—a well-known method. The telephone, being exceedingly sensitive and rapid, is most suitable, whilst a galvanometer would be too slow, and its use, in fact, impossible for the researches I have been making.

Numerous details have been necessarily omitted in this rough sketch of the instrument. Suffice it to say that it is perfectly adapted for the object sought, viz., the investigation and measurement of the self-induction which takes place in all wires.

By all previous methods the measurement of the resistance of a wire is taken when the current has been already some time in action, or, to use an expression of M. Gaugain, when the electricity has arrived at its "stable period." In telegraphy, electric lighting, and all applications using rapid electrical changes, another period has to be considered, viz., that during the rise and fall of the current; this he named "the variable period," and it is in this period that all the phenomena of induction takes place.

To observe the *stable* period, the current is continuously passed through the bridge (and consequently through the wire under observation), and the interruptor being placed in the telephone circuit allows us to find the exact resistance of the wire, free from all induction or change in the wire itself.

To observe the *variable* period, the interruptor or rheotome (making at will from 10 to 100 contacts per second) is placed on the battery circuit, the telephone being joined as shown in the diagram.

By means of a switch or reversing key these changes are made as rapidly and often as desired.

If there were no static or self-induction, no loss of time, or change of resistance, then the result from these two periods would be equal; but this is never the case, for we find that when the resistance is balanced to a perfect zero for the stable period, loud sounds are given out in the variable period, requiring a fresh adjustment or balancing of the resistance of the wire, as well as a compensating opposing induction current from the sonometer to balance the self-induction. If we balance the resistance or the extra currents alone there is no possible zero, but when both are compensated we find at once a perfect zero for the resistance of the wire, and for its extra currents.

INDUCTIVE CAPACITY OF METALS.

The results of the following experiments prove that the force and duration of the extra currents depend upon the kind of metal employed as a conductor, its molecular condition, and the form given to the conductor, independent of its resistance or the electromotive force of the primary currrent. The increase of force by increased length is proportional to the length of wire less its additional resistance, but with wires of the same length increased cross section or diminished resistance does not produce a corresponding increase in the electromotive force of the extra currents.

The time of charge and discharge of the wire is independent of the electromotive force of the extra currents; for, if we compare currents of equal electromotive force obtained from copper and iron, it will be found that the duration of these currents in wires of 1 mm. diameter will be seven times slower in iron than in copper, and a still greater difference will be found in larger wires. The longest or slowest charge and discharge takes place in the purest soft iron, and have a constant ratio of increase with increased diameter of the wire; my experiments giving for wires of double the previous section, or for wires of four times less resistance, a mean increase of three times its previous duration.

The electromotive force of the extra current in different metals will be seen in the following table, and in order that the values obtained from the sonometer may be clearly understood I have reduced the results to comparative values.

The table of values were obtained on wires of similar length, having been repeated on a similar series of lengths ranging from 10 cm. to 5 metres. The instrument is sufficiently sensitive for pieces only 10 cm. in length, and the results from the short lengths were as pronounced and accurate as those for greater lengths. I may add that the instrument shows no effects or traces of static charge for the lengths mentioned.

TABLE I.

Wires 1 mm. in diameter. 30 cm. in length.

Soft Swedish iron	100	Copper	20
Soft puddled iron	78	Brass	13
Swedish iron, not softened	55	Zinc*	12
Soft cast steel	41	Lead	10
Nickel*	34	German silver	7
Hardened cast steel	28	Mercury*	2
Cobalt*	24	Carbon*	1

* Being unable to procure wires of these metals, they were tested in the form of strips, and compared with similar strips of copper. Mercury was in a glass tube 2 mm. in diameter; carbon tested in the form of electric light carbon from 3 mm. to 10 mm.

The above table is only true for wires of 1 mm. diameter, as the effect depends on the size of the wire in relation to the nature of the metal. In soft Swedish iron a diminution in the electromotive force of the extra currents takes place with each increase in its section, and this has been

8. *Comptes Rendus de l'Académie des Sciences*, Paris, Dec. 30, 1878, and Jan. 20, 1879; *Proc. Roy. Soc.*, vol. xxxi., p. 527, 1881.

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partially foreseen by Maxwell,[4] who said: "The electromotive force arising from the induction of the current on itself is different in different parts of the section of the wire, being in general a function of the distance from the axis of the wire as well as time."

From this I expected that the increase of electromotive force by an increased section would not increase directly as its sectional increase; but I was not prepared to find, as my experiments prove, that after a certain maximum diameter of wire has been reached a marked decrease in electromotive force takes place with each further sectional increase, and that this maximum is variable with each metal.

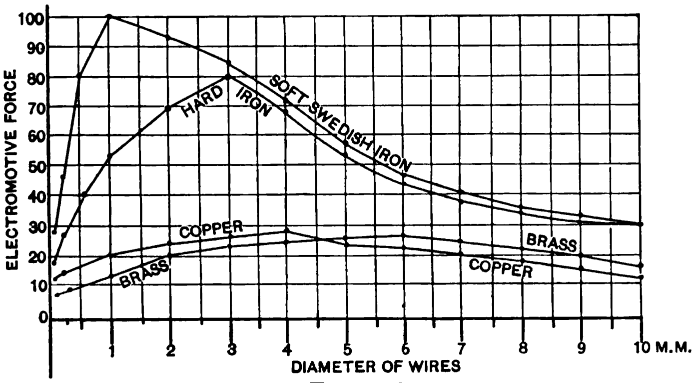

FIGURE 2.

The diagram shows a rapid rise of force in soft iron from an extremely fine wire of 0.10 mm. section to a maximum at 1 mm., from which point there is a slow but continued decrease of force with each increase in the size of the wire, until at the comparatively great diameter of wire of 10 mm. the force is but a fraction more than in the extremely fine wire.

Hard Swedish iron has a less initial force in the fine wire, and does not arrive at its maximum until the wire has 3 mm. diameter, being then nearly of the same force as soft iron of the same diameter; the fall from this point, is somewhat similar, but less than soft iron until at 8 and 10 mm.; soft and hard iron have absolutely the same values.

A curious change of values at different diameters will be seen in copper and brass. Copper, having nearly double the initial force in fine wires, arrives at its maximum at 4 mm.; but brass creeps slowly up, passing copper at 5 mm., arriving at its maximum at 6 mm., and finally, in the large section 10 mm., it has more force than copper, their positions being completely reversed.

I have been unable to obtain wires of different diameters of other metals; but zinc rods of 10 mm. gave a still higher rate than brass, whilst in small diameters its force was less. For non-magnetic metals it is probable that the greater the specific resistance of the metal the greater will be the diameter of the wire before the fall commences.

Carbon is remarkably free from self-induction, and although there is a rise of force in rods of 3 mm. to 10 mm., it is so small as to be hardly measurable. German silver rises with comparative rapidity, indicating that with wires of 20 mm. its force would equal that of copper. Carbon, therefore, seems peculiarly adapted as a resistance when used in the variable period of electric currents.

INFLUENCE OF PARALLEL CURRENTS.

The instrument being well adapted for showing the slightest change in the self-induction by the reaction of one portion of the current upon the other when in the same direction, as in a coil, or in the opposite direction, as in a parallel return wire, I made a series of experiments in order to observe the influence of different metallic conductors in this respect.

Two silk-covered iron and copper wires of similar diameter and length (1 mm. diam., 2 metres in length) were each formed in a single loop of 66 cm. diameter. The extra currents from iron were, as usual, six times stronger than those from a similar loop of copper. On closing the loop by bringing the opposite sides in close proximity and thus making a parallel return wire (the current ascending on one side and descending the other), I found that the reaction of currents in opposite direction was very different with different metals, the results depending more upon the nature of the metal than upon the proximity of the wires.

There was a reduction of the previous force of the extra currents in iron, when forming a parallel return wire, of 15 per cent., whilst the reduction in copper was 80 per cent. Thus the currents in copper are far more influenced by an external wire than those in iron; consequently a telephone line having its return wire in close proximity should invariably be of copper, as not only is its specific inductive capacity less, but this is again reduced by the return wire, so that its self-induction is far below that of iron.

In order to observe the influence of currents in the same direction, the same wires were formed into a close coil of twelve turns of 2 cm. diameter; and from the known effects of parallel currents in the same direction we should expect a greatly increased effect. It was so in the case of copper, but iron was far less under the influence of an external parallel current; the strength of current in iron when formed into a coil being 57 per cent. greater than that of a single wide loop, whilst in copper the increase was 404 per cent., or seven times the increase of iron; and although iron when in a single wide loop had six times the force of copper, the comparative strength was reversed when the wires were wound as a coil, the extra currents from the copper coil then having 14 per cent. greater strength than that from iron, and this difference could be rendered more evident by employing longer wires.

Thus copper, as regards extra currents, is far more sensitive to the influence of external currents than iron, and the true self-induction from its own current can only be obtained by a straight wire, where the return wire is at such a distance that its influence is not appreciable.

REACTION OF CONTIGUOUS PORTIONS OF THE SAME CURRENT.

It is well known that currents in separate portions of the same wire (as in a coil) react upon each other, and I felt convinced from the preceding experiment that self-induction is entirely due to similar electro-magnetic reactions between contiguous portions of the current in its own wire. Let us assume that an electric current consists of a bundle or an almost infinite number of parallel currents, the limit being a single line of consecutive molecules; then each line of current should by its electro-magnetic action react on each of the others similarly to wires conveying separate portions of the current, and the self-induction should be at its maximum when the lines are in the closest possible proximity, as in a conductor of circular section, and far less when separated, as in one of ribbon form, where the outlying portions are separated by a comparatively great distance: there would still remain, in the latter case, the reactions from the near portions on each other, and these should again be reduced by cutting the ribbon into a number of thin narrow strips separated, except at their junction, to a sufficient distance to prevent any marked reaction.

My experiments prove that this assumption is an experimental fact; for we can reduce the self-induction of a current upon itself to a mere fraction of its previous force by simply separating as indicated the contiguous portions of a current from each other, the results proving that a comparatively small separation, such as is obtained by employing ribbon conductors in place of a wire of the same weight, reduces the self-induction 80 per cent. in iron and

4. *Electricity and Magnetism*, vol. ii., p. 291.

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35 per cent. in copper; and if we still divide the current by cutting the ribbon into several, say 16, strips (separating the strips at least 1 cm. from each other), then the combined but separated strips show a still greater reduction, being 94 per cent. in iron and 75 per cent. in copper.

The following table shows the comparative reduction of self-induction by employing ribbons and parallel separated wires:—

TABLE II.

Flat strips compared with round wire 30 cm. in length.	Copper	Iron	Parallel wires 30 cm. in length.	Copper	Iron
Wire 1 mm. diameter..	20	100	Wire 1 mm. diameter..	20	100
STRIPS.			SINGLE WIRE.		
0.25 mm. thick, 2 mm. wide..................	15	35	0.25 mm. diameter....	16	48
Same, 5 mm. wide.....	13	20	Two similar wires. ...	12	30
" 10 "	11	15	Four "	9	18
" 20 "	10	14	Eight "	8	10
" 40 "	9	13	Sixteen "	7	6
Same strip rolled up in the form of wire....	17	15	Same, 16 wires bound close together........	18	12

The resistance of a conductor, or even the nature of its metal, has less influence on its self-induction than the form given to that conductor, the 1 mm. wire in the above table having a less resistance than the strip of 2 mm. wide, and a greater than any of the wider strips; but through all these variations we notice a gradual fall from the wire to the widest strip or ribbon, with a marked return to its previous force when the ribbon is rolled up in form of a wire.

The reduction is greater in iron than copper, but its increase when rolled up is less than copper, thus agreeing with the previous observations on the difference of iron and copper to external reactions.

A still greater reduction takes place when we separate a current by using parallel wires separated 2 cm. from each other, as shown in the table. We then have a similar reduction to that produced by cutting the strips into several separate conductors; and we again remark that when the wires are brought close together (forming a stranded wire) copper rises in a far greater proportion than iron, the 16 fine iron wires twisted together as a stranded wire having 88 per cent. less induction than a solid wire of similar weight; a remarkable fact being that whilst a solid iron wire has an inductive capacity 80 per cent. greater than a solid copper wire, this is completely reversed when each metal forms a stranded wire of the same weight as the solid, for iron then has 33 per cent. less self-induction than copper.

It is not necessary to use extremely fine wires when we desire to reduce the inductive capacity of iron to that of copper, for I have formed stranded wire rope of 16 strands of wire where each wire was 1 mm. in diameter, giving 75 per cent. less induction than a solid wire of the same resistance. I purchased an ordinary wire rope of 6 mm. diameter, having 6 strands of 6 wires, each 0.5 mm. diameter: this gave the best result yet obtained, for, on comparing 3 metres of it with a similar length of solid iron wire of the same resistance, the 36-stranded wire had only 5 per cent. of the amount of induction shown by the solid wire.

Steel, in the form of ribbon or stranded wires, shows a similar effect to that of iron; and it is a remarkable fact that, whilst the extra currents from a steel or iron wire 4 mm. in diameter are extremely slow, and impossible to balance without reducing the time of the sonometer current (by the introduction of an iron core), the ribbon or stranded wire requires no such compensation, for its feeble extra current is exceedingly sharp, and can be balanced to a pefect zero, being actually quicker than that of a solid wire of copper of the same resistance. This fact I regard as one of great importance for telegraph lines and lightning conductors.

A curious effect takes place if we employ mixed conductors, such as a compound wire of copper and iron. A fine coating of copper reduces the induction in a solid iron wire in a marked degree. This I found to be due to the difference of electromotive force of the extra currents in the two metals, for, by employing a fine copper wire parallel with an iron wire, and in contact at the ends, the extra current was reduced 60 per cent. The copper wire, having a lower electromotive force, probably acts as a shunt; but if the capacity of the iron has already been reduced, as in a sheet or stranded wires, then the addition of a single copper strand increases the force, as the electromotive force of the extra currents of copper is above that of stranded iron.

There has been for many years a discussion as to the merits of the round form as compared with the tape or ribbon form for lightning conductors. Those in favor of the former based their conclusions on experiments which gave a negative or no apparent difference between the two forms of conductors. Those in favor of ribbon conductors, as Sir W. Snow Harris, Professor Guillemin, and many others, based their opinion upon marked differences found when using high charges of static electricity. The latter supposed that there was a difference between discharges of static electricity and voltaic currents of low tension, and that the advantage recognized by almost conclusive experiments was due in a great measure to conduction by surface.

In the year 1864, Professor Guillemin and myself, as members of the Commission de Perfectionment of the French Telegraph Administration, were charged with the mission of testing the comparative merits of the lightning protectors then used upon their lines.

Our method of experimenting consisted in joining an insulated conductor to a short fine iron wire connected directly with the earth return wire. A Leyden jar battery charged by a Rhumkorff coil was discharged through this conductor, burning or deflagrating the fine iron wire. This wire represented the telegraph instrument requiring protection, and by placing the lightning protector connected with the earth in advance of the fine iron wire we could observe the amount of protection afforded. This answered extremely well for feeble discharges, but with the full power of our battery the fine iron wire was invariably destroyed, even with the best lightning protectors which are universally used to this day. Noticing that we could not give absolute protection to the fine wire by lightning protectors, we tried the effect of joining the conductor direct to a separate earth wire in advance of the fine wire, and with powerful discharges the wire beyond the protection was invariably burnt, notwithstanding that we connected the conductor direct to earth by a copper stranded wire of 1 cm. diameter.

Professor Guillemin continued these experiments after my departure for Russia, and he found, by employing a thin sheet of copper as a conductor to earth in place of the copper stranded wire placed in advance of the fine iron wire, that the wire could be perfectly protected. The theory of this action was not understood at the time, and the experiment has not received the attention it deserved; but the mutual reactions of contiguous currents shown in this paper explain the phenomenon in the fullest degree, for we see that a sheet or ribbon conductor has far less self-induction than a wire or rod of the same material.

I am fully convinced from the results of my experiments that an enormous retardation or resistance is evident in all conductors at the first portion of the variable period, and that this is due to self-induction, the current thus arousing an antagonist in its own path sufficiently powerful, when the primary current has a high electromotive force, to deflagrate or separate the wire into its constituent separate molecules, as shown by Dr. Warren de la Rue.

It is also evident from my experiments—which are

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easily repeated, with invariable results—that a flat conductor has far less self-induction than a solid of circular section during the variable period; and even with a constant current, as in the stable period, this form of conductor, as first shown by Professor George Forbes, would, from its greater radiation, convey more current with less heating than a wire or rod of the same resistance.

Lightning conductors are intended to convey a current of high intensity during an exceedingly short time, and should therefore be designed so as to convey this current with as little opposition from self-induction as possible; consequently, I regard a solid rod of iron as the worst possible form for a lightning conductor. The conductor, if of copper, should be of ribbon form, say 1 mm. by 10 cm. wide, or if of iron, of numerous stranded wires or a wide ribbon of similar conductivity to that of the copper.

SELF-INDUCTION OF A TELEGRAPH LINE.

A telegraph line may be considered as a single loop: the earth taking the place of a return wire can only affect the self-induction by a diminution of its effects, as in the case of a parallel return wire.

Mr. W. H. Preece has lately read a most valuable paper on "The Relative Merits of Iron and Copper Wire for Telegraph Lines,"[5] in which he shows, by comparative rates of speed with the same instrument, that on a copper and an iron line of 278 miles in length (between London and Newcastle), whose resistance and static capacity were rendered equal, there was an increase of speed in the copper line of 12.9 per cent. as compared with an iron wire.

I have not been able to test the relative speeds obtainable by telegraph instruments on wires of different material. The results in every case would depend very much on the apparatus employed, but I have considered the question from a point of view independent of the instruments.

There is a remarkable difference in the resistance of a wire during the stable and the variable period, the measurements taken in the stable period giving no real or approximate idea of what its resistance really is during the rise of the current in the wire.

A curious fact in relation to telegraphy is that all measurements are made during the period of a constant flow of current, whilst all instruments—particularly those requiring rapid changes in the current—work only during the rise and fall of the current, as in the variable period. Telegraph engineers, however, have not made the mistake of assuming that there is no difference in the resistance of a wire in these two periods, as it is well known that electro-magnets and coils have a far higher resistance during the rise and fall of a current, and coils simply augment the effect of a straight wire of a given length.

The present method of testing by Wheatstone bridge has been adopted because we had no practical means of measuring the resistance in the variable period; and I do not believe that this can be accomplished except by a similar method to that which I have used, in which the resistance and self-induction are separately measured and balanced, and by the use of an exceedingly rapid and sensitive instrument of observation, as the telephone, in place of the sluggish galvanometers, no matter of what construction.

The speed of telegraph instruments is greatly influenced by the resistance of the wire. I said in 1883[6] that a great difference would be found in the resistance of an electrical conductor if measured during the variable instead of the stable period, and I have made numerous experiments with the view of ascertaining to what extent this difference would probably be felt on telegraph lines.

I have already mentioned that the time or the duration of the extra currents increases rapidly with the section of the conductor; consequently comparisons can only be made between wires of similar section for speed, or wires of similar resistance for differences in their variable period.

In measuring the resistance of a wire during the two periods, I have found it best to avoid the use of resistance coils, the simplest method being to measure or balance a given length of wire in one period, and then observing how much lengthening or shortening of the wire would produce a similar zero in the second period. Suppose that we commence by balancing the resistance during the variable period, and fix the sliding communications at the point at which we have obtained a perfect zero; we can now change to the stable period by means of the commutator; and as we no longer find a zero, but extremely loud sounds, we gradually lengthen the wire under observation until we have again a perfect zero. The amount of wire added to its previous length shows the difference in resistance between a conductor in which there are rapid electrical changes and that wherein the flow of current is constant.

Amongst numerous experiments I will cite a single example. I measured or balanced the resistance of an ordinary soft iron wire, 1 metre in length and 4 mm. diameter, during the variable period, and found that it required in the stable period exactly 2 metres 58 cm. to balance the previous resistance. Similar tests on a sample of best charcoal iron wire, as used on our telegraph lines, gave still more remarkable results, showing 225 per cent. difference between the two periods; for 1 metre of this wire had, during the rise and fall of the current, precisely the same resistance as 3 metres 25 cm. in the stable period. This shows that an iron telegraph wire has with rapid currents *more than three times* the resistance during its actual work than that supposed to be its true resistance.

It was difficult on short lengths to find any change whatever in the resistance of copper or stranded iron wires in the two periods; the time of discharge being excessively rapid, I could only estimate the resistance by the electromotive force of the extra currents, or by forming the wires into coils (when a remarkably great difference is shown), and then estimating the proportional amount due to its own reaction; by this method I was enabled to detect 10 per cent. difference for a solid copper wire, and but 8 per cent. for the stranded rope of 36 iron wires. The difference in time of the duration of the extra currents between solid iron and copper and between solid iron and stranded iron is so great that we may consider a solid iron wire to belong, comparatively speaking, to the class of slow conductors, whilst copper and stranded wire would belong to the rapid.

I have shown a difference of resistance in the variable period between copper and iron of at least 200 per cent.—a difference which will be felt on instruments depending upon rapid changes, such as the telephone; and it is evident that the more rapid the contacts of a telegraph instrument the greater will be the difference between copper and iron. There is consequently a great electrical advantage in those instruments which require only a single current for each letter, as the economy of electrical impulses allows them to work at a comparatively high speed; the duration of the extra currents would be shorter than the length of their contacts, and consequently they would perceive very little, if any, difference between the two periods, or between iron and copper. If we use three or five currents for each letter, we must necessarily send them faster or closer together; and the difficulty increases in a rapid ratio with the speed of intermittent or reversed currents, until a point is reached (as I have shown in the case of best charcoal iron) where, whilst nominally working through 500 miles, we are practically working through an equivalent resistance of at least 1,500 miles, and this without taking into account the static charge, which would, in addition, from its comparatively extreme slowness of charge and discharge, cause the apparent resistance of the

5. British Association, Aberdeen, September, 1885.

6. Discussion on the paper of W. H. Preece on Electrical Conductors, *Proc. Inst. Civil Engineers*, vol. lxxv., 1883.

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wire in the variable period to be much greater than I have mentioned.

In Mr. Preece's experiments he finds a difference of speed of 12.9 per cent. between iron and copper, which is far less than the difference of resistance during the variable period which I have obtained; and this may be explained by assuming that the speed of the reversed currents which he employed was only near the border land of extra currents. I am convinced that if Mr. Preece could have increased the speed of the instruments he would have found a far greater difference between iron and copper; and if I regard the results of a solid iron wire alone, I should regard iron as unsuitable for telegraph instruments requiring extremely rapid currents. Copper would reign supreme if it were not for the fact, which I have discovered, that stranded iron wires have even a greater rapidity of action than copper.

PHYSICAL CHANGES IN THE CONDUCTOR.

Self-induction not only depends on the nature and form of its conductor, but also on the physical state of the metal, as already shown in the case of soft and hard iron. I felt convinced that the higher force in iron was due to its magnetic capacity, and to prove this I tried the effect of heating the wire to a bright red heat, or 1,000° C. It is well known that iron loses its magnetic properties at bright red heat, and I found that its self-induction then fell to less than that of copper. This would have been conclusive had it not been for the fact that a different result takes place when the capacity of the iron for self-induction has already been reduced, as in the case of thin flat sheets of iron; in this case there is no disappearance or further decrease of induction except that due to the extra resistance caused by the increased temperature of the strip. Now, as the strip was highly magnetic when cold, and lost this property at red heat, there should have been some change in its self-induction if this were due to the magnetic nature of the iron alone. This requires further researches before a probable explanation can be given.

Iron is peculiarly sensitive to all physical changes. Mechanical strains of all kinds hardens the wire, and its influence on its self-induction can at once be detected. An iron wire under a moderate longitudinal strain loses 40 per cent., and its capacity is then less than unstrained cast steel.

Iron well annealed has much less resistance than the same iron when hard drawn, and soft iron is generally employed for telegraph lines; but during the variable period a curious reversal takes place, as then soft iron has a higher resistance than hard iron. This apparent anomaly is easily explained if we compare the far higher self-induction of soft iron. Work is done at the expense of electrical energy, and the apparent higher resistance is due to the greater electro-magnetic action in soft iron.

An iron wire shows traces of remaining circular magnetism after the passage of a continuous current, reducing the following extra currents 10 per cent.

Magnetizing the wire, or subjecting it to mechanical vibrations, when used separately, produce no apparent change in its inductive capacity, but a remarkable change takes place if either of these is used in conjunction with a constant current. Let us pass a constant current and heat the wire to red heat, allowing it to cool with the current on; or, in place of heat, magnetize the wire; or, in place of magnetism, give the wire mechanical vibrations; the result of either of these being a strong internal circular magnetism, due, I believe, to the loosening of the magnetic molecules, allowing them to rotate with greater freedom under the influence of heat, mechanical vibrations, or magnetism. A wire thus treated has no longer its previous self-induction, which has fallen 60 per cent.; and as the circular magnetism becomes fixed when the vibrations cease, this molecular structure remains a constant as long as we employ intermittent currents in the same direction, but the structure disappears the instant a reverse current is sent; and this explains why we have more than double the amount of self-induction from reverse currents, as each reversal destroys any remaining magnetism due to the previous passage of the current.

If we compare the electromotive force of self-induction on a given length of wire with the secondary currents generated in a second but independent circuit, we find that the self-induction is the most powerful, the secondary currents generated in a close independent copper wire being 20 per cent. less than its own wire. There is no difference between the self-induction of a current and the secondary currents; they are, in fact, as proved by Faraday, part of the same phenomenon. The self-induction is evidently due to the electro-magnetic reactions of the primary current, and as magnetism permeates space, the separation of the wires only serves to insulate the primary, but does not affect its magnetic influence; and, as I have shown in the reactions of contiguous portions of the same current, so the magnetic reactions perpendicular to the axis of the current continue through the wire to all surrounding wires; and if we call the currents in the independent wires secondary, they are still secondary whilst enclosed in the wire of the primary; and as the reaction will ever be the strongest in the axis of the current, so will these currents be necessarily stronger than those induced in independent wires. For this reason we should be able to obtain extra currents of far higher electromotive force than would be possible from a secondary wire of the same length.

It was my intention, on the reading of this paper, to demonstrate by practical experiments some remarkable properties of extra currents of high electromotive force; but I find that the subject and apparatus employed require a longer description than the limits of this paper allow. I must also leave aside for the present my experiments upon coils of different forms with cores of different metals. These, as well as other results obtained, indicate that there is a large field of useful research in many directions, each, however, requiring special studies according to the object we may have in view.

The record of numerous experiments, of which this paper is only an abstract, shows that the nature of the metal as well as its physical condition has an important influence upon the self-induction of an electric current, and by a study of the reactions produced by the contiguous portions of a current, and by application of the results, we may, as in the case of iron, transform an extremely slow conductor into one of the greatest rapidity; I therefore hope not only that these researches may be of interest from a scientific point of view, but that the results obtained may be of practical utility in some of the numerous applications of electricity.

SOME POINTS IN ELECTRICAL DISTRIBUTION.[1]

BY PROF. GEORGE FORBES.

When I had the honor, just a year ago, to give a course of Cantor lectures to this society, on the distribution of electricity, the subject had not till then been treated in a systematic manner. When I was this year asked to read a paper before the society, I eagerly availed myself of the opportunity to take up the straggling threads, and say a few words on the subjects which were previously but inadequately treated.

Allow me to remind you that in my lectures I described five different ways of laying the mains, each one depending upon a different method of connecting the dynamo machines and lamps. Three of these may be called direct systems, and two indirect. Each system has special advantages when applied in suitable cases, and when an engineer is designing a scheme of distribution he carefully

1. A paper read before the Society of Arts, February 19th, 1886.

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considers the *pros* and *cons* of each system as applied to the special case, and very often he has to go through the whole calculations of the scheme according to several different systems.

The three direct systems are the parallel, series, and parallel-series methods of attaching lamps to the main conductors.[2] The two indirect systems are with the use of secondary batteries and secondary generators. Each of these systems is capable of being varied in the details of its application, and each is specially applicable to particular cases.

The first or parallel system is generally most suitable for small installations, but the cost of conductors becomes extravagant when the area is extended, except in very special cases. The series system is at present only used for arc lights, sometimes with the insertion of a few glow lamps in parallel to replace an arc lamp.

The third system is admirably suited in every case where the number of lamps in use at any time is constant, and may perhaps be modified so as to be applicable to other cases. Smaller conductors can be used on this system than on the first, and this effects a very great economy.

Having recalled these points to your notice, I need say no more, as I treated these three systems and their modifications very fully in my Cantor lectures.

I thought I had spoken strongly enough about the enormous cost of the main conductors, and the necessity for selecting that size of conductor which is the most economical. We must not use too small a conductor, for then the waste of energy in heating the conductors would be enormous. Nor must we use too large a conductor, for this means buried capital. We must select that size which balances one cause of loss against the other so as to give the maximum economy.

I find, however, that, while this axiom has been accepted as such in this country, some writers from America still try to uphold the fallacious views which have hitherto been in vogue there. I have noticed more than one criticism from America, by people asserting themselves to be connected in some way with some of the Edison companies, who protest against my statement that the three-wire system effects an economy of copper of only 25 per cent. over a two-wire system. The difference between us is that I start with the *axiom* that we are to use the most economical size of conductor. My critics start with the *assumption* that they shall use a conductor which shall waste exactly 10 per cent. of the energy. In this way they use a conductor which is not the most economical, and they show a saving of 62½ per cent. of copper over the two-wire system, but with a possible extra waste of energy of 62½ per cent. I said in my Cantor lectures, and I repeat it this evening, that this manipulation of figures may suit American financiers, but it is not electrical engineering.

Before proceeding to discuss the indirect methods of distributing electricity, which is the main point I wish to touch upon to-night, I wish to supplement my remarks on series lighting by a statement of what has been done in the last year. I expressed a hope that more attention might be given to the lighting of houses by glow lamps in series. I further showed that it was only by means of a constant current flowing through glow lamps in series that the regulation of each lamp could possibly be effected on economical principles. This regulation must be accomplished by altering the length of the filament in the lamp. This has never yet been done, but if inventors once realize the importance of the object to be attained, I feel sure that we shall not have long to wait for the solution of the problem. Now I am delighted to be able to inform you that during the past year at least one inventor has been applying himself to the placing of glow lamps in series. Mr. Bernstein, who has paid so much attention to the system of glow lamps, has worked out the problem of using lamps of low pressure and large current in series. He has boldly taken extreme measures, and proposes to use lamps of 6 volts and 10 ampères. And here he has got over a difficulty I referred to in my Cantor lectures. I said that there was no economical way of preventing a broken lamp from extinguishing all the others on the series. Passing part of the current through a shunt whose resistance is 100 times that of the lamp, would be very expensive if we had in use lamps of the ordinary type, but with a lamp whose resistance is a fraction of an ohm, the expense would be trifling. When the lamp breaks, the current in the shunt is increased so as to release a contact which short-circuits both the lamp and the shunt.

I still think, however, that the loss of energy by heat conduction at the terminals, may be very great in lamps of so low a resistance. Mr. Bernstein tells me it is 10 per cent. Still I can well foresee that, even if a very sensible loss of energy occurred, the economy and convenience of using such a system might be amply sufficient to warrant its adoption in many cases.

I congratulate Mr. Bernstein on his work in the past, and would urge him to develop this idea more fully, and I can assure him that I, for one, will give the fullest consideration to the system when preparing the plans for electric light installations.

I should like also to take this opportunity of congratulating other makers of electrical appliances on the advances which have been made since the date of my Cantor lectures. I should like especially to congratulate Mr. Swan on the improvements he has made in the manufacture of glow lamps; the Messrs. Siemens and Messrs. Crompton on their successful construction of very large dynamos; Messrs. Elwell and Parker on their great improvements in the details of construction of dynamos and motors; and the Electrical Power Storage Co. on the continued improvements in their secondary batteries. I would equally congratulate Messrs. Willans and Crompton for the continued improvements in steam engine governors, for keeping the current from a dynamo or the pressure at any point in the circuit constant; likewise Mr. Ferranti for having brought out an electric current meter which promises to fulfill all the wants of engineers and the public in this direction; and last, but by no means least, Messrs. Woodhouse and Rawson for various new devices which will go far to assist in designing and carrying out many schemes of lighting; and I would specially mention their automatic cut-out, adjustable to any strength of current, which, though not so new as some other devices, has only been brought prominently to my notice during the past year, and whose simplicity and reliability give me great confidence in employing it. I must not fail to include here, as a subject for congratulation, the rising esteem in which secondary generators are held, and the improvements which have been made in their manufacture.

When I add to this list the admirable lamp-holder of Mr. Alfred Swan, Varley's adjustable carbon resistances, and other small but useful accessories, I think you will agree with me that the facilities at the disposal of the engineer for designing a satisfactory scheme of electric lighting, and which have been added to his store during the past year, are very abundant.

About one of these appliances, I should like to add a few words.

First, I may say that the electric lighting act was rendered abortive, if for no other reason, simply for the want of an electric current meter which was in all points satisfactory. In the year 1882, a patent was taken out for a meter in which the current passing round an electro-magnet created a field where mercury was placed, which rotated when the current passed through the mercury from the centre to the exterior of the field. If the magnetism be proportional to the current, and the friction be proportional to the square of the velocity, then the number of turns completed in any time is a direct measure of the total

2. In my Cantor lectures I used the terms multiple arc, series, and multiple series. I prefer the terms now advocated.

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quantity of electricity which has flowed through the meter in that time. The marked improvements introduced into this meter by Mr. Ferranti consist in the perfection of the magnetic circuit, and the introduction of an almost frictionless mechanism for correcting the revolutions and showing them on dials like a gas meter.

I have many of these appliances on the table which any member of the audience may examine at the conclusion of the paper.

In referring to my Cantor lectures, let me make a few remarks about a double table which I introduced to assist engineers in calculating the size of mains required in any installation. These tables have been copied into a number of technical journals and books of reference, but in nearly every case there is no word of explanation how to use them. I have found these tables of such paramount convenience that I think it right to call attention to them once more. The economical size of mains depends upon three variable factors—the price of laying down a ton of copper mains, the interest to be charged on the capital sunk in mains, and the value of an electrical horse-power for the number of hours that is to be utilized during the year. My table is divided into two parts. Look along the line in the second part which relates to the percentage on capital which you propose to use, until you come to the column relating to that price of copper which you propose to use, and you then find a number printed which we may call the auxiliary number. Now take the first part of the table and look along the line which relates to that value of a year horse-power which you propose to use, until you find the auxiliary number; the heading of that column of figures tells you the size of main per 1,000 ampères which is most economical to use according to the data you have employed.

I will now remind you of the position in which we were left after a full discussion in the Cantor lectures of the three direct systems of distribution. The parallel system, or the three-wire system is admirably adapted in cases where the farthest lamp of the district is within 200 yards of the central station. So soon as you go to greater distances the cost begins to increase in an alarming ratio. Hence this system would be applicable to a large district only by having engines and dynamos put down at a very large number of small stations. Now, a station is not worked economically unless the engine driver and stoker are fully employed, and the maximum economy cannot be reached with less than about 1,000 h. p. Thus the parallel system is only applicable to cities so densely populated as to have a consumption of about 10,000 16 c. p. lamps in a radius of 200 yards. But in most districts of this class space is valuable, and a large number of such stations would be very expensive. We must, then, in the parallel system of distribution, be content to work at a cost which is above that of the ideal of economy. There are many cases where the great simplicity of such a system does actually make it worth while to sacrifice this ideal of economy, and when an engineer is consulted on such matters it is his duty to estimate the exact loss from not strictly following the ideal economical rules before adopting or rejecting this system. In order to make a parallel system effective, the central station must use distributing boxes, the methods of placing which are described in my Cantor lectures.

The cure for all these evils would be found if a thoroughly satisfactory system on the parallel series plan were known. In that case high tension electricity might be used involving smaller conductors. Thus the central station might be at a distance, where land is cheap, and it might be of any size, so that all the works would be in the same place, as they are in gas distribution. Here the only departure from the ideal of economy lies in the length of the conductors to the district which has the supply. But these conductors are comparatively small, and no engineer would recommend the adoption of such a system unless he found that the economy of having the works out of the expensive district counterbalanced the extra expense in mains.

Now I regret to be compelled to say that, after discussing all the ingenious plans on the parallel series system proposed by Mr. Edison and others, I arrived at the conclusion that at this time there is no parallel series system of distribution which is quite satisfactory. I do not say that such a system cannot be devised, but I do say that at this moment no such system is available to the electrical engineer, except in the case where the same quantity of electrical energy is consumed in any district at all hours during which the current is being used. There are some cases where it will pay to insert equivalent resistances when lamps are put out. These cases are rare, but they must not be lost sight of by the engineer.

Having in the Cantor lectures discussed all the direct systems of distribution, I will complete my outline of this part of the engineer's profession by an examination of the two indirect methods which I formerly touched upon only lightly, viz., secondary batteries and secondary generators.

SECONDARY BATTERIES.

I have been given to test about a dozen different kinds of secondary batteries, of which I have found some four or five to be good, and the others mostly worthless. I can say this, that at the present moment secondary batteries can be supplied by certain makers which are to be relied on with careful usage, and which gives us 70 to 80 per cent. return for the energy expended.

Now it might be asked what are the advantages of storing the energy if you lose 25 per cent. by doing so. The first advantage is that a breakdown in the machinery does not then interfere with the supply. The second advantage is that the steadiness of the supply does not depend upon the speed of moving machinery. The third and great economical advantage is that your expensive engines and dynamos are paying interest 24 hours of the day, instead of only a few hours, by doing their work; and a smaller supply of engines and dynamos suffices.

Now this is all very well, so far as having secondary batteries at the point of supply is concerned, but it does not help us much so far in the great problem which we have attacked, viz., that of electrical distribution. But the improvement of secondary batteries led to great hopes of a cheap system of distribution. It was said, "Put your generating station at a distance, on cheap ground, carry a current with high potential through light conductors to the district to be lighted. Pass the current through some thousand accumulators in series, placing these in batches of 50, say, each, in cellars, to light up a small district." The original idea was to keep the service wires permanently attached to the two ends of each set of 50 cells.

Now this plan is very beautiful if only it would work. But it will not work. The consumption being small from some of the cellars and large from others, and the same charging current going through all of them, the cells become overcharged in many cases, and this is injurious.

Another plan was proposed which I described in my Cantor lectures. This was to introduce an arrangement to indicate when the cells were fully charged. By having two complete sets of batteries in each cellar, the indicator caused a rocking switch to act which switched the fully charged battery off from the charging mains on to the service mains, and at the same time switched the second set, which had, up to that time, been supplying the service mains, on to the charging mains. Here I would point out that, independently of the fact that we have no reliable indicator to show when the cells are fully charged, this only moves the difficulty back one step. For it will often happen that both sets are fully charged, and yet we are obliged to send current through one of them. This plan was tried at Colchester, but of course it had to be abandoned. If we had a true indicator to show

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when the cells are fully charged, the more sensible plan of using it seems to be to cause the indicator to disconnect the cells from the charging mains and connect the charging mains metallically. There would of course be a great fall of potential in lamps immediately after switching off the supply current, but the charging of the cells might be done by day or after midnight, during which time lamps are not very much used. I think that even this small difficulty might be got over by causing the indicator when it acts to increase the number of cells which lead to the lamps.

I suppose the most reliable indicators which could be used are those depending upon the specific gravity of the solution or the weight of the negative (oxidized) plate. Unfortunately, it is seldom found that a number of cells working in series become charged at the same time.

In fact, it is not very generally known that the most satisfactory plan for charging secondary batteries is to do so in quantity or parallel. When this is done, every cell is fully charged exactly at the same time, and all give off gas at the same moment. If there be any possibility of short circuiting, however, fusible plugs or other cut-outs must be inserted.[3]

To have a thoroughly satisfactory installation, it is necessary that the cells may be left in their secluded retreats without attention for long periods. I think I can safely say that cells can be so left if fairly treated. But the question is whether any scheme of distribution hitherto considered does give them fair treatment. If attendants have to be continually going round to inspect cells, this expense must be carefully calculated so far as is possible, and taken into account.

Now let me say a few words as to the improvements in secondary batteries. First, I may say that there is now no doubt that they can be made, and are made, by several makers of so good a construction that they can be used for years. I will not fix the number of years, because none of the most perfect ones have yet failed. Secondly, it seems to be conclusively proved that not only does no buckling take place, but there is no fluting or blistering if the plates are originally good, and if the air has not been allowed to reach them. Thirdly, we know that in over-charging them we do not injure them, but merely waste current. These are important facts, and are all we want for an installation where the state of the cells can be always under examination. For central station lighting we want something more. We want the cells to take current from the dynamos when they require it. For this we must have an indicator on the cells to work a switch, according to the state of charge of the current. Up to the present no satisfactory master cell has been devised. Those which depend on the gas given off do not act equally promptly with currents of different strength. The most promising system is one in which the state of the cell is shown by the specific gravity of the liquid. Very little ingenuity is required to develop this into a satisfactory system. But we cannot depend upon one master cell since it is only when charging in parallel that all cells act alike. If we have several master cells in each battery, all of which must act together to cut off the dynamo, I think we might depend upon their action. The function of the switch is—first, when the E. M. F. of the battery is too high, to cut out the dynamo circuit from the battery, to give a through connection to the dynamo current, and to switch in two additional cells to the lamp circuit; second, when the E. M. F. of the battery is too low, to break the charging current, to connect the battery to it, and to cut off two cells from the lamp circuit. These are all ordinary things which can easily be done.

But even without automatic action of this sort there are many large installations where it would be economical to use secondary batteries even if attendants had to be continually examining the state of the cells. The engineer who is designing an installation, if he does his duty, calculates the cost of every method of working which can be feasible.

The cost is of course an important item, and were it not that this system introduces a great saving in copper conductors and machinery, it would often be too expensive to work. We may take the cost of batteries at about £3 per lamp of 60 watts. The saving in copper conductors is proportional to the number of batteries put in series. There is also a saving in dynamos and engines. If we take four hours as the average time of using the lamps, we charge them, say, for six hours in the day time, and we use the dynamos as well as the batteries during the greater part of the night. Thus we require batteries and dynamos for only about one-half of the number of lamps generally in use. This brings the cost of batteries down to £1 10s. per lamp, and the cost of dynamos and engines from about £1 per lamp (the usual cost for a direct service) to 10s. per lamp. This makes a total cost of £2 per lamp, as against £1 by a direct service. When we have made a further reduction for diminished size of conductors, and an increase for additional attendance, we are in a position to compare the two systems. But these figures vary so enormously that it is impossible to estimate them unless one has the details before him. We may say safely, however, that in large districts there is economy in secondary batteries, and in small districts in a direct service. But the advantage of not being dependent on the constant perfection of machinery is very great, and avoids the necessity for so complete a duplication of the parts. Of course the cost of working must also be made out, allowing for a loss of at least 20 per cent. in transforming through the secondary batteries.

The number of ways of using secondary batteries is great, but there are no engineering difficulties in the distribution, and I may, therefore, content myself with having drawn attention to the general advantages of using them.

Among the many special appliances used in this kind of work, I am glad to be able to show you some useful things supplied by the Electrical Power Storage Co.

Perhaps the most important of these is a switch for large currents, in which a number of concentric tubes have a longitudinal slot into which the arm of the switch is forced. The split tubes have a certain amount of spring, and literally cut into the arm of the switch, and so make good metallic contact. The one before you has been thoroughly tested with 1,500 ampères passing through it.

Another appliance is an automatic switch to reduce the number of cells in the lamp circuit when the dynamo is charging the cells and *vice versa*.

A third is a cut-out to prevent damage to the charging dynamo by an accidental falling off of speed. It has this peculiarity, that it puts the battery in circuit again so soon as the dynamo resumes its functions.

In concluding this part of my subject, I would draw your attention to the scheme of lighting the Vienna opera house. The dynamos are by Messrs. Crompton, of 72,000 watts each, and are driven by direct acting Willans and Robinson engines. I am told that they give an electrical horse-power for 3.7 lbs. of coal. The secondary batteries are supplied by the Electrical Power Storage Co. The three-wire system is adopted, 110 cells are ordinarily in use with each circuit, and six additional ones are available to keep the electric pressure constant.

SECONDARY GENERATORS.

I now come to speak of secondary generators, and since the principles which regulate their action are rather novel, it may be well if I spend a little more time in describing their action than I would otherwise do in a lecture treating chiefly of the manner of laying main conductors.

Everyone knows the principle of the induction coil. It consists of a core of iron surrounded by a coil of insulated

3. Even in this case we may have a partial short circuit, which will drain the current and yet will not cut out the cell.

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wire called the primary coil, and by another one of insulated wire called the secondary coil. The secondary usually contains a larger number of turns and finer wire than the primary. The current in the primary is alternately made and broken by a simple automatic means. This magnetizes and demagnetizes the iron core. This is equivalent to introducing and withdrawing a magnet into and out of the secondary coil, and sets up currents in the secondary coil.

The electromotive force created in each turn of the secondary coil is measured by the number of magnetizations per second, and by the strength of the magnetization. The latter is generally proportional to the number of turns in the primary, and to the current flowing through it. Thus the electromotive force in the secondary coil depends, 1, on the number of turns in the primary; 2, on the number of turns in the secondary; 3, on the strength of current in the primary; and 4, on the number of makes and breaks in the primary current. Thus by having a large number of turns in the secondary coil, and a small number in the primary, a very high electromotive force can be obtained from a small battery connected with the primary.

If, on the other hand, a high tension interrupted current were sent through the fine wire coil we could get a large current from the thick wire coil.

Now, to feed a number of glow lamps in parallel, we require a large current, but this requires a large conductor. Here it was proposed to use a high tension alternate current (which acts just like an interrupted current) by a thin conductor from the works to the place of consumption, and there to transform it into a current of large quantity.

Then, again, another idea was thrown out. This was to carry the alternate current by a thin conductor round a large district, and at intervals to pass it through the first coil of induction coils, using the second coil to supply the lamps. Thus we should have a high tension current disconnected from the service conductors, and furnishing them all with a low tension current.

Induction coils used in this way have been called secondary generators or transformers. The perfection of manufacture of such apparatus consists in getting a maximum of induction and a minimum of heating. This has been admirably accomplished in the generators of Messrs. Gaulard and Gibbs. Instead of wire, the coils are made of copper discs, or flat rings split at one point, and with ears projecting outwards at the split. These discs alternately belong to the primary and secondary circuit, and successive discs of each circuit have the ears soldered together in such an order as to make up a spiral. The iron core is, of course, made of iron.

Although the even discs belong to the primary and the odd ones to the secondary, it does not follow that alternate discs should be coupled together. We may couple the 1st, 5th, 9th, etc., together, and also the 3d, 7th, 11th, etc., so as to form two secondary circuits, which may be combined in parallel. The number of possible modifications of this sort is very great.

When the primary coil is magnetizing and demagnetizing the iron core, the latter sets up a counter electromotive force in the coil, and thus the current is largely diminished. But when there is no external resistance in the secondary coil, that coil being short circuited, then any magnetization and demagnetization of the core starts a current in the secondary coil, opposite in direction to that in the primary and almost equal to it. Thus the iron cannot get much magnetized, for it is surrounded by two opposing currents almost equal in amount. In this case, therefore, the primary has little or no counter electromotive force opposing it, and consequently it flows more freely. This explains a thing which often puzzles the beginner, viz., that with a constant electromotive force in the dynamo the current in the primary is stronger when the secondary circuit is closed than when it is open.

Very little energy is expended in magnetizing and demagnetizing iron wires. Thus there is really no loss of energy in the transformation, except that due to the heating of the conductors of which the coils are constructed, which is equal to the square of the current multiplied by the resistance. The loss of energy, which could not be accounted for, has been shown by Prof. Ferraris to be less than one per cent., and the practical efficiency of the generator amounts to as much as 95 per cent.

The theory of the secondary generators is very like that of the alternate current dynamo, if the reversals of magnetism of the armature were given by reversing the currents in the field magnets instead of by mechanical motion.

Coming now to distribution by secondary generators we find we must use the same principles as in direct distribution.

Parallel Distribution.—Let us take this case first. To do this economically we might lead two thin wires over the district and couple secondary generators to them. The condition of being able to have constant electric pressure in the lamps is that the electric pressure at the terminals of the primary should be constant. Here we meet the same difficulty as was experienced in direct supply. Consider three generators—1, 2, 3, figure 1. If the lamps are all on in all three cases, then the pressure for No. 3 is less than

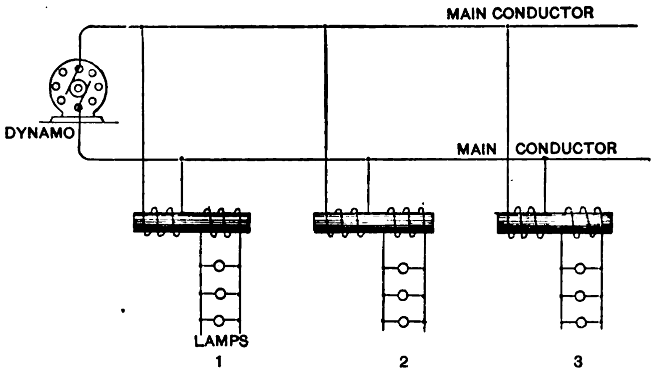

FIG 1.—Secondary Generators in Parallel.

for No. 2, and that again is less than for No. 1. Suppose you try to rectify this by using lamps of lower pressure at the far station. In this case suppose the lamps in No. 2 are extinguished, then the pressure in No. 3 will go up and tend to injure the lamps. If you try to correct this at the central station you will lower the pressure of No. 1 till perhaps it only burns red. This difficulty is exactly the same as in the direct service. The remedy

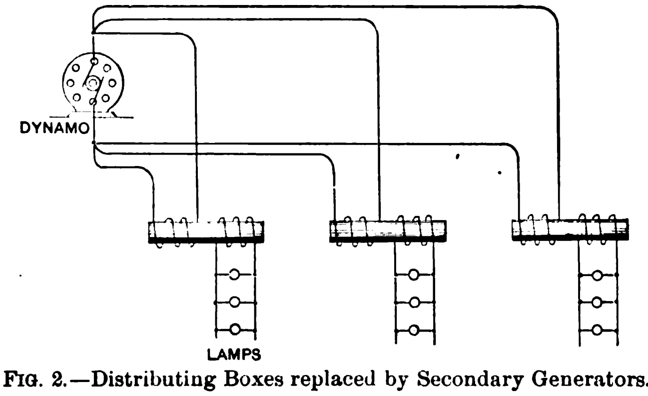

FIG. 2.—Distributing Boxes replaced by Secondary Generators.

is of the same kind. You must use the generators as distributing boxes (see my Cantor lectures, 1885), with separate wires from the engine to each generator, each one being fed with a different pressure from the engine house. Figure 2 shows this arrangement. There is no objection to it except 1, that you must use a large number of conductors, and 2, you introduce the full pressure of the high tension current into each house.

Finally, we come to distribution by generators in series.

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Here we have the best effect. A single wire figure 3, goes round the circuit; if a double wire is used, to prevent affecting telephones, it is half the weight, and generators are alternately put on one wire and the other all round the district, and each pair of wires ends at a point far from the station. Suppose we use 10,000 volts, we may have 100 generators in series, each using 100 volts, or we may make any other arrangement. If it were done as I say, then following out the data of my Cantor lectures, a wire of one square inch section will carry current enough for 100,000 lamps each consuming 60 watts.

In this arrangement we must send a constant current through the circuit. This is actually done by the introduction of resistances. It ought to be done either by an electric governor on the steam engine, or by compound winding the alternate current machine, a matter about which there is no difficulty at all.

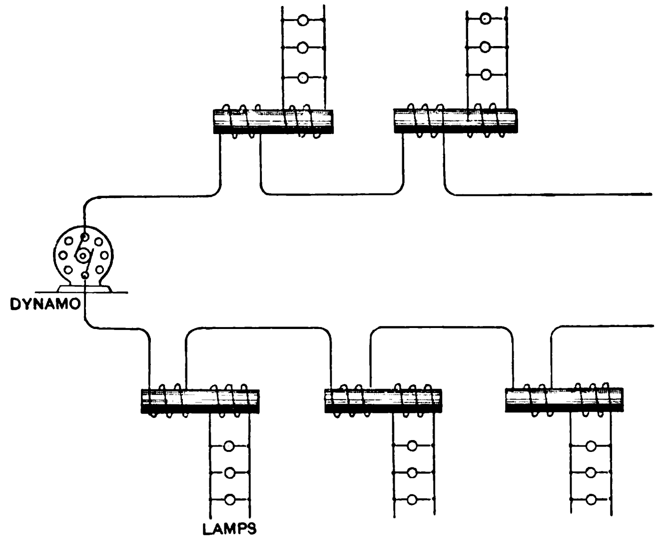

FIG. 3.—Secondary Generators in Series.

But how are we to attain to constant electric pressure in the lamps when we have got our constant current? This is a problem which has puzzled many people, and many have come to the conclusion that it is impossible to do it without mechanism. This used to be done by automatically introducing the iron core farther or less far into the coils. It is now done without any relative movement of the parts. This is the last triumph which has been added to a series of laborious experiments which year by year have brought us nearer to a solution of our difficulties. I am not at liberty to explain the *modus operandi*, but I have seen it at work, and it is very satisfactory.

The theory of secondary generators has been so little studied, except by specialists, that I have thought it might be advantageous to many if I added to this paper the formulæ which represent the electric current and pressure as depending upon the resistances and mutual induction of the various parts. These data will be found in an appendix to the present paper.

I do not think it would be consistent with the objects of this paper to describe the specific differences between different kinds of secondary generators, or to attempt to give reasons for choosing one of these forms rather than another. I would merely draw attention to the brilliant experiments on self-induction by Professor Hughes, described in his introductory address as president to the society of Telegraph Engineers and of Electricians. Professor Hughes has discovered a new and hitherto unnoticed source of waste of energy in self-induction, to remedy which it is essential to have the coils of the secondary generator made of discs.

I should also like, before leaving the subject, to dispel a growing error from the minds of some electricians. In speaking of different secondary generators, some persons are in the habit of speaking of one inventor's generator being used on a parallel system, another on a series system. This distinction is quite illusory. A generator made on any system is equally suitable for all kinds of distribution, and if an inventor states that his generator is only suited for one system of distribution he displays his ignorance, and shows that he has yet much to learn before he can say he understands the theory of secondary generators.

Last year, when speaking in my Cantor lectures, I said that the Grosvenor Gallery installation would be followed with interest by engineers. I considered that it was a new test. Up to that time the method had been applied only to light districts where the number of lamps was constant. It was not proved that the method was suitable to the cases where lamps might at any moment be extinguished. Two things were necessary for this, 1, regulation of the current from the dynamo, and 2, automatic regulation of the electric pressure in the secondary circuit. Neither of these had then been accomplished in a manner which satisfied me, and I certainly considered it was a very bold step on the part of Sir Coutts Lindsay to adopt a system which was then so imperfect.

I am satisfied now that self-regulation of the secondary circuit is sufficiently perfect for practical purposes, even when the generators are in series; and I have pointed out to Messrs. Gaulard and Gibbs a further development which, in my opinion, will make their system even more perfect. The one weak point in the Grosvenor Gallery installation is the regulation of the current from the dynamo. Out of the four or five different methods by means of which this can be done, the worst has been applied up to this time, viz., hand regulation. The result is a frequent flicker in the lights. Still, when we consider that seven miles of route has been covered by the wires of this small association, and that on the whole great satisfaction is expressed by the users of the light, I must say that Sir Coutts Lindsay and his friends are to be congratulated on the great steps they have made towards success.

In conclusion, I wish briefly to allude to the present condition of electric lighting, and the prospects of economical distribution from central stations.

I have always maintained that there were three causes which retarded the progress of electric lighting:—1, financial speculation; 2, the electric lighting act of 1882; and 3, the unsuitability of the schemes of electrical distribution propounded by the contractors. I will say a few words on each in turn.

From the year 1881 to 1883, this country was the scene of a most senseless speculation, started by clever men of business, who took advantage of the interest in electric lighting caused by the Paris and Crystal Palace exhibitions, and supported by dupes whose ignorance of electrical matters was only equaled by their want of common sense as business men. These men combined to purchase for large sums the right to use the apparatus of some particular manufacturing firm in a special locality. They never asked any competent person whether this firm's apparatus was better or worse than that upon which there were no royalties to pay. Those who were not clever enough to get out of the affair before the bubble burst were the sufferers, and the consequence was a panic in connection with electric lighting which has hardly yet subsided.

With matured knowledge confidence is again being restored, because the public learn from competent and disinterested persons that economical electric lighting can be accomplished without the necessity for paying the heavy royalties formerly demanded.

I trust that the warning of 1882–3 will not be lost on financiers, and that they will not be misled by untried but tempting schemes unsupported by capable men of science.

The next cause which has deterred electric lighting is the act of 1882. This is an act to give undertakers the right to break up streets in order to lay conductors, under certain conditions. It is these conditions which are so unjust.

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Some of our legislators, looking at the monopolies which exist in gas supply, are afraid that electric lighters will raise another monopoly. Consequently, they determined to hamper the electric lighting industry with conditions different to those imposed upon gas, and more stringent. They succeeded well, for they laid down such conditions that no sane man would invest in such a speculation. You would have thought it natural, I doubt not, that if the gas monopoly was truly so very irksome, the encouragement of a rival illuminant would have been the best cure for the evil, whereas our legislators acted as if they were parties interested in maintaining the gas monopoly, for they imposed such restrictions as rendered it impossible for electricity to be supplied to the public. Let me name one of their wise provisions. At the end of 21 years the local authorities can, if they please, buy from the company supplying electricity, the whole of their plant at the price of old material, without paying a farthing for good-will or future profits, or past expenses in experimental and unprofitable work.

If, then, a company, after 21 years, were just making headway, and paying a dividend of five per cent. on their capital, the corporation would buy them up for perhaps a third of that capital, and get 15 per cent. But the case is even worse if the company is not yet earning a fair dividend, for then the corporation may hang over the company like a usurer over his victim, and each seven years it has the right to purchase the plant or not, and on the same terms as before.

Now, I agree with those who contend that electricity should be allowed to compete with gas under the same disabilities, and with the same advantages. This is not doubling a monopoly; it is splitting it in two, and destroying the monopoly, by allowing competition. If our legislators are not trying to uphold the gas monopoly, they must take this view. In any case, the public have shown that they will not submit to be deprived by legislation of this illuminant. The board of trade, I hear, have perceived their error, and are prepared to yield a little; but if they do not enable us to have electricity supplied to us, we, the public, must force their hand.

Still, electric lighting is not quite dependent on this act. Local authorities have no penalties, and I would strongly urge them to take the matter up, for we have now arrived at a stage when it is safe and profitable to establish electric lighting on a large scale.

Again, you must remember that the disabilities of the act apply only to those who lay their conductors underground and wish to break up the street. Sir Coutts Lindsay has taught us how to defy the electric lighting act by passing the wires overhead. Those wires do not suffer like telegraph wires in snow storms, for the electric current melts the snow.

The third cause which deterred the progress of electric lighting, was the unsuitability of schemes of distribution which were proposed. I was impressed with this weak point at an early date. Sir William Thomson was the first to touch on the matter when he announced his law of the economical size of conductors. But the engineer had no tables to guide him as to the safety of these sizes of conductors in the matter of heating. I attacked this problem first in order to clear the way for scientific methods of dealing with distribution. In a paper read before the Society of Telegraph Engineers and Electricians, in 1883, I computed from the facts well known to physicists, the heating of different sized conductors with different currents, whether the conductors were bare, insulated or buried. I had already, in a communication to the British Association, in 1882, shown by experimental evidence, that the generally accepted laws required modification when we dealt with small wires.

The way being thus cleared, I attacked the problem of distribution generally, studying the various schemes which had been proposed or put in practice. My conclusions were published in the Cantor lectures in 1885, and the most useful result was to announce a series of definite rules which must be attended to in order to provide an economical distribution. Since then some progress has been made, and the present paper will, I hope, bring the subject pretty well up to date.

The work which I undertook has been laborious, but it has been a very humble effort. I have brought forward hardly a single fact which could not have been foreseen by the competent engineer. But I think I have saved others from wasting their energy in repeating much of the work which is laborious; and I also trust that the outcome is a set of rules to guide those engineers whose purely scientific knowledge may be a little defective from falling into the gross errors which have been so apparent in nearly all attempts at lighting by electricity on a large scale which have been made in the past.

I now close the subject for a time, and if the labor I have bestowed upon it leads in any slight measure to establishing one department of electrical engineering on a sound scientific basis, I shall feel that in the work I have undertaken I have been of some little use to my generation.

APPENDIX.

The following formulæ give the currents and electromotive forces, on the assumption that the magnetism of the core varies as the sum of the currents in the two coils.

The E. M. F. of the dynamo is assumed as being—

$$\text{E} \sin. mt$$

Then the primary current $= \text{I} \sin. (mt + \gamma)$

secondary current $= \text{I}' \sin. (mt + \gamma')$

$$\text{I}^2 = \text{E}^2 \frac{\text{C}^2 + r'^2}{r^2 r'^2 + (r + r')^2 \text{C}}$$

$$\text{I}'^2 = \text{E}^2 \frac{\text{C}^2}{r^2 r'^2 + (r + r')^2 \text{C}^2}$$

Where C is a constant;

r = resistance of primary circuit;

r' = " secondary circuit.

Also the potentials at primary terminals $= v$;

and " secondary terminals $= v'$;

where $v = \text{V} \sin. (mt + \Phi)$

$v' = \text{V} \sin. (mt + \Phi)$

$$\text{V}^2 = \text{E}^2 \frac{(\rho^2 r^2 + (\rho + r')^2 \text{C}^2}{r^2 r'^2 + (r + r')^2 \text{C}^3}$$

$$\text{V}'^2 = \text{E}^2 \frac{(r' + \rho')^2 \text{C}^2}{r^2 r'^2 + (r + r')^2 \text{C}^2}$$

ρ and ρ' being the resistances of the primary and secondary coils.

DISCUSSION.

Prof. Hughes, F.R.S., said in his latest researches he had found that the maximum induction in iron took place when the iron was in the round form. If it was flattened, so that the contiguous portions of the current became separated from each other, the current was very weak; it had not one-tenth of its previous capacity. In the case of copper wire flattened, the reduction in the self-induction was about 50 per cent. Taking iron wire and passing a current through it, if you wish to have a secondary current parallel to it, the self-induction prevented the current acting on the secondary coil; in fact, the force of the electric current was used up in doing internal work. By flattening it, it re-acted on another wire to its full force, so that the energy which would have been used in self-induction was transformed into the secondary current. He had not the slightest doubt that if this method were adopted, enormously more power could be obtained from the secondary coil. When two wires were flattened, the portions contiguous to each other did not re-act on each other with the same strength, but re-acted on any portion near; consequently, when there was another flattened sheet superposed, you had it in the nearest possible proximity. It was very remarkable that the same results at which he had arrived theoretically should have been worked out experimentally by Messrs. Gaulard and Gibbs, and they had arrived at the best possible conditions he could conceive for constructing a secondary coil. He had only one fault to find with it; the generator itself seemed perfect, but it required intermittent currents, and, therefore, it seemed to him there must be a loss in the line.

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Mr. Gaulard (who spoke in French) thanked Prof. Forbes for his remarks upon the actual conditions and future prospects of the apparatus with which he was associated. He also thanked Prof. Hughes for his expressions respecting the mode of construction adopted, and in answer to the objection as to the great loss caused by the use of alternate currents for leads of great length, he said he could rely upon the experiments made with their apparatus, and reassure Prof. Hughes entirely on this subject. Their apparatus was constructed with two parallel circuits, forming spirals in the same direction. In order to obtain in the secondary circuit a variable electromotive force, they had contrived to unite in parallel and inverse directions the two circuits, and they had found that if in these conditions they sent through them an alternating current, the difference of potential at the ends of the spirals was directly proportioned to the resistance in the leads. If, on the other hand, they interposed in one of the connections a resistance, they found that the difference of potential at the two ends of the secondary circuit was, to a certain extent, directly proportioned to that resistance. From these observations it followed that if the leads consist of two parallel wires, and currents in opposite directions are sent through, not only no phenomenon of induction on the outer external circuit can appear, but no self-induction on these two leads can exist any more.

Mr. Kapp said he did not know much about the distribution of electricity, but he should like to add one more to the list of improvements which had been placed at the service of the electrical engineer, and that was the reduction which had been made in the speed of the dynamo. Machines were now running at half the speed of those constructed a few years ago, and in this way the chances of failure were enormously reduced.

Mr. B. Drake remarked that Prof. Forbes had drawn attention to the different ways in which electricity might be distributed for lighting purposes, but had not fully compared the relative advantages and disadvantages of the different systems. On behalf of secondary batteries, he would claim advantage in the practical impossibility of totally extinguishing a district through the failure of a single wire. No doubt there were many points which might be claimed on behalf of secondary generators, such as the first cost being less, and there being stronger metals in use which would be likely to last longer than lead plates, but at the same time the contingency of a station being extinguished all at once was an important consideration, and the fact of the engine having to be run to its full power whenever all the lights were required would more than balance the small extra cost of the accumulators in the first instance. The question had been raised as to the different details of apparatus necessary in connection with secondary batteries; they had been experimenting with every kind of apparatus for the last 18 months, with a view to ascertaining how far it was really worth while to complicate the system by putting in automatic contrivances, and after designing all sorts of apparatus, they had come to the conclusion that the whole thing ought to be kept as simple as possible. When a cell was practically empty you required only 2.2 volts to charge it with a certain current, whereas to get the same current through it when the cell was full required over 2.5; the cutting off of a definite number of cells was therefore practically not worth the cost of the apparatus. It was, however, found advisable to introduce some kind of automatic switch in any installation where the attendant ever had to leave the engine. There was again the question of the regularity of the light. If the engine power varied at all where secondary generators were used, that variation was transmitted throughout the whole district; if a bearing ran hot, all the lights felt it; and in addition to that, there was the variation which Prof. Forbes now said had been nearly overcome, which was due to varied consumption at different points of the circuit. With secondary batteries none of these evils occurred, and if some apparatus could be made reliable for cutting them in and out when fully charged, it seemed to him the solution of the problem would be complete. He agreed with Prof. Forbes that the specific gravity was the right principle to adopt in cutting out the accumulators, and that the master-cell system would be much improved by having two master cells which would have to be completed before the automatic cut-out would work. The difficulty with the specific gravity apparatus was this. The carrier which carried the whole apparatus had to float as well as the hydrometer, and in order to do that the cell containing it had to be enlarged. In that way the bulk of the acid was enlarged, and consequently the range in specific gravity became so extremely small that you could practically do nothing with the small variation of the hydrometer. On the other hand, with the extremely small space which was necessary to get any appreciable variation, you had to employ such a small apparatus that you could hardly rely on its working properly. The only way to get any results was by a system of relays, and that was difficult near accumulators, because the contacts got corroded by the acid. No doubt the advocates of the other system would be able to point out objections to secondary batteries, and he should be much interested in hearing them.

Mr. Mordey thought the carbon resistance gauge shown was very similar to that which had been made for years by the Brush corporation, consisting of a series of small carbon plates in a case, with a screw or lever arrangement to enable the resistance to be varied by alteration in the pressure. The principle had been used by Mr. Brush in his automatic regulator. The original principle he believed was due to M. Clerac, who communicated it to Prof. Hughes in 1867. With regard to lamps of low resistance, he might say that on some circuits at Eastbourne, and also at Brighton, the plan had been in operation, not with so low a resistance as Mr. Bernstein used, but so low as to allow of three lamps in a group being used, instead of eight or nine; each lamp taking a current of 3.3 ampères, the normal working current being 10 ampères. The manipulation of a group of lamps was very much simplified when the number was reduced; and if it could be reduced to one, and a constant current could be maintained through the circuit, the perfection of simplification would be attained; but even where three had been used in a group with about 15 volts at the terminals, the manipulalion of each group was not a serious matter. Where people employed a large number of lights, they might object to turn out eight or ten, but the same objection did not apply to a group of three. He should like to ask if there was any advantage in using secondary generators in the manner shown in the diagram in parallel; it seemed to him that all the effect thus obtained could be obtained much better by the ordinary direct supply. The cost of leads and the whole of the problems connected with the question would be much the same in each case. Another point in connection with secondary generators was of great scientific interest, and that was as to the actual loss of energy in the iron of the core due to the rapid magnetization and demagnetization. There had been a great deal of discussion of late years as to whether any energy was really lost in this way, and it was a very difficult subject to work at, because it was almost impossible to eliminate the effect due to eddy currents, and that due to the turning over of the molecules, as Prof. Hughes would call it. In an ordinary dynamo machine, where the reversal of polarity was not so rapid, only 400 or 500 revolutions a minute, and the molecules only required to be turned over 800 or 1,000 times a minute, the difficulty was not felt, but in secondary generator coils, where the reversal of magnetism took place thousands of times in a minute, it would be very different, and he should like to know if the actual loss had been ascertained.

Mr. Gaulard, in answer to the observations respecting the great loss which might result from the retardation in the molecular vibrations, produced by a very great number of alternations—an opinion based upon certain facts observed in the use of a current having 1,000 alternations per minute—he would point out again that, in the experiments made by the International Jury of Turin upon the secondary generators by the most exact method, the calorimetric method, the current used had 16,000 alternations per minute; the yield had been proved to be 95 per cent. This is the greatest number of alternations obtained till now by an alternate current machine of the largest type known, and perfectly sufficient, he thought, for producing the highest electromotive force which may be wanted from a practical point of view.

The chairman, Prof. W. G. Adams, F.R.S., drew attention to the several points which had been raised by Prof. Forbes, and which had been brought out in the discussion, such as the relation of the size of conductor to the mode of distribution, and especially the part played by secondary batteries, and, again, the important applications of secondary generators so ably explained by M. Gaulard. Now that electric lighting was not going forward with such hot haste as it was two or three years ago, those who were connected with it had more time to think about the best and most efficient methods of doing the work, and the lull would be found to be a time of great profit to electric lighting. We may be thankful to Prof. Forbes for making the question of the size and arrangement of conductors so much his own, and for giving us the benefit of his researches in this direction. We must also thank him for so ably bringing before us in the Cantor lectures, and in his paper this evening, the results of a great deal of thought and experiment on the different systems of lighting. Thanks to his and other researches, we may say that electric lighting is on a much more stable basis than it was three years ago. When it was stated that you could depend on getting out of storage batteries 70 or 80 per cent. of the energy employed, it was evident that a great step had been made during the last three years. Coming to the question of secondary generators, a very successful experiment had been made—indeed, it was almost more than an experiment—by Sir Coutts Lindsay. He might also refer to the experiment made some time ago by Messrs. Gaulard and Gibbs, in which they lighted up part of the Metropolitan railway—from the Edgeware road station to Aldgate in one direction, and Notting Hill Gate in the other—from one central station. The apparatus exhibited this evening showed that even then they had made very great progress, and that they had gone far ahead of the position to which they had then attained.

Prof. Forbes, in reply, said some of the points raised had been already answered. M. Gaulard had replied to Prof. Hughes by telling him of the effect of the double line; and he would observe that in doubling the line it was not necessary to double the quantity of metal, because, as shown in the sketch of the series arrangement, when you doubled the line, you tapped both wires, and therefore made the wires half the section they would otherwise have been. He ought to have congratulated Mr. Kapp on

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the improvements he had effected, but he should congratulate him on increasing his magnetic induction and the capacity of his machine, more than on diminishing its speed. It was perfectly true there might be less chance of failure in a machine when running at half speed than at the speed it used to run, but at what a tremendous cost that safety was obtained. The machine ought to do double the amount of work it did at that reduced speed. When there was a central station to light, the dynamo must be run at a reduced speed, but it must be made up for in another way by increasing the size. When there were large districts to light, it would be economical to have large machines going at comparatively slow speeds. When Mr. Drake came to look at the paper, he thought he would find that he had given full credit to the advantage he had mentioned of a district never being put in darkness through one wire breaking. He was sorry to hear that the sum total of eighteen months' work was, that they could not leave the batteries alone to automatic appliances to work themselves, and he trusted that Mr. Drake would reconsider that question. He hoped to see secondary batteries largely used in central station lighting, but if it involved the necessity of attendants going round to look after them and switch them in and out, it would be a serious drawback to their introduction. He ought to have mentioned that it was Mr. Drake who originally suggested to him the use of two master cells. In reply to Mr. Mordey, of course he did not mean to say that the use of carbon plates as an adjustable resistance was new, but he drew attention to this instrument of Mr. Varley's because he believed it was new, and it possessed advantages he had not seen in any previous arrangement. It was perfectly adjustable by the screw, and did not require knocking on the table to shake the pieces apart, as he had found with Mr. Brush's apparatus. With regard to the advantage of using secondary generators in parallel, he would point out that if the station were at a great distance, very thin conductors might be used to the generators. You might use a primary circuit of any series, and take as the secondary coil a number of discs in parallel, and so use a high tension current, thousands of volts in the primary, and yet have only 100, or whatever was required, in the house, and have all the economy of thin conductors. With regard to the loss of energy in magnetizing and demagnetizing, he agreed with M. Gaulard that it was an extremely minute quantity which could not be detected; the loss when a core of iron wire was used was very small indeed.

The chairman then proposed a vote of thanks to Prof. Forbes, which was carried unanimously.

DYNAMIC ELECTRICITY.

BY CARL HERING.

CHAPTER I.

Review of Electrical Units and Fundamental Laws.

ELECTRICAL phenomena, being, like all other merely different correlations of force and matter, are in many respects quite analogous to mechanical phenomena. Their nature may therefore be much more readily understood by comparing them with well-known mechanical effects, in which case calculations involving electrical quantities will appear to be much simpler, and more readily intelligible. Understanding the mechanical relations, it is then very easy to understand the electrical ones by their analogy. The necessary electrical computations will then appear quite as simple, and perhaps even more simple, than mechanical ones in common use.

Unlike mechanical phenomena, the quantities in connection with electricity cannot be measured in pounds, feet, or gallons, by reason of the different form of forces with which we have to deal. They must, therefore, be measured in units of their own. There is no such thing as distance in electrotechnics, nor weight, at least not appreciable weight, nor can any electrical quantities be measured in cubic inches. It is therefore not proper to say that these quantities exist in different forms in electrical phenomena; but it is quite admissible to assume that there are quantities in electrotechnics which have the same function as distance, weight and capacity in mechanics, and that the analogues of these may be used to illustrate the nature of different electrical phenomena and to assist in showing how electrical calculations should be made.

This may be best shown by an example. The ordinary well-known centrifugal blower, consisting simply of a number of fans rotating in an enclosed vessel, will, when in action, produce a compression of the air at one place, and a rarefaction of air at another; that is, it will force the air out at one part, and draw it in at the other. If the two ends of a tube are attached to these two points, a current of air will be caused to flow through it in a definite direction. This very simple machine affords a very good illustration not only of the simple quantities in electrotechnics and the elementary laws of electrical action, but also of other points which are less frequently well understood, but by a clear conception of which, electric batteries, machines and phenomena connected with them, appear much simpler, and can, therefore, more readily be subjected to quantitative investigation.

The mechanical pressure of air which is generated in the blower, being of a positive character (having a density greater than that of the atmosphere) at one part, and negative (or suction, or less than the atmosphere) at another part, corresponds precisely to the electrical pressure, or *potential*, in batteries and machines. In both cases, if they are allowed to equalize themselves, they will produce a current in a certain direction—from the positive to the negative in the external circuit, and from negative to positive within the machine or battery itself. This pressure, which in mechanics is expressed as so many pounds per square inch, corresponds in electrotechnics to what is termed electrical pressure, electromotive force, potential, or tension, and which is measured in volts.

In the case of air, the zero or normal pressure corresponds with that of the atmosphere, for when air in a confined vessel is at atmospheric pressure, there will be no current produced if the vessel is made to communicate with the air. In the case of water, the zero level is taken as that of the ocean. Similarly there is a zero level or pressure of electricity with which other pressures can be compared. This is the natural pressure of electricity in the earth itself. The earth, as is well known, may be regarded as a reservoir of electricity of infinite capacity, and its pressure is taken as zero. If one pole of a battery or other generator is connected with the earth and a current tends to flow from it to the earth, then that pole is assumed to be positive; and if the other pole be similarly connected, the current will tend to flow from it to the generator, and is therefore assumed to be the negative pole. As almost all electric lighting apparatus is isolated from the earth, it makes no practical difference whether the actual pressure is above or below zero. All that concerns the electrician is to know what is the difference between the two pressures at the two poles of the battery or other generator; hence the term "difference of potential." The zero pressure of electricity is, however, important in considering ground connections of machines and lines, as will be seen hereafter.

As in mechanics a pressure is necessary to produce a current of air, so in electrical phenomena an electromotive force is necessary to produce a current. A current in either case can never exist without a pressure to produce it. From this the important law is deduced that a difference of electrical pressure cannot exist at two points of a conductor without generating a current between these two points, except when there is a counter pressure in that conductor in the opposite direction, as, for example, in the machine itself. This law, which seems self-evident, is frequently of use in solving certain problems.

This current of electricity, expressed in ampères, represents quantity per second, just as it would do in an air current, and it is very similar in many other respects to the current of air produced by a blower.

The actual quantity of electricity itself is measured in coulombs, which correspond to quantity of air. Just as in the case of air, this quantity may exist in a state of rest, as in the charge of a Leyden jar, or a charged cloud; and in that state it may be at any pressure, either greater or less than that of the earth. If in that state it is allowed to equalize itself, through a conductor to the earth or to another confined quantity of electricity at any other pressure, a current will flow as in the case of air. If this quan-

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tity be limited, as in a statically charged Leyden jar or condenser, it will equalize itself suddenly in the form of a momentary current or spark, in the same way as the confined gases of ignited powder in a pistol suddenly equalize their pressure with that of the atmosphere. If, however, this pressure, which is consumed, be continually replaced by some means, in the same proportion in which it is consumed, the current which was momentary in the first case will then become continuous. This is precisely what is done by an electric machine, battery, or other generator. It continually replaces the electrical pressure which is consumed or equalized through the lamps and conductors connecting its poles, just as the centrifugal blower continually replaces the pressure which is again consumed in the place where it equalizes itself or the work is done.

It will be seen from this that the object of an electric machine, battery or other generator, is to maintain a continuous electrical pressure, or electromotive force, the amount of which shall be equal to that which is consumed, for in that case only can a continuous current be established and maintained. Properly speaking, its object is not to generate electricity, for there is practically an infinite quantity of that in the earth itself, and were it only the quantity of electricity which is wanted, there would be no need of machines. Electricity in quantity without pressure is useless, for it cannot be made available, under such conditions, for operating lamps, telegraphs, etc. It is a current which is required, and this can be maintained only by a constant renewal of pressure, which is what the machine, battery, or other generator does. As electricity is neither consumed in lamps nor actually generated by machines, it follows that to each electric machine or battery there must be two conductors or wires—one to lead to it the supply of electricity at low pressure, and the other to lead off the electricity of high pressure, while on the other hand, in the lamps or other apparatus, when the pressure is consumed, the function of the wires is precisely the reverse.

The truth of the proposition that electricity is not actually produced in the machines nor consumed in the lamps, may be demonstrated by measuring the actual quantity of current flowing in through one wire and out through another, which will always be found the same. The action is precisely analogous to what takes place in the centrifugal air blower, which, as we well know, generates pressure, but not air. It may also be compared to a hydraulic pump, which generates the pressure of the water, but not the water itself; as much water must flow into the pump at one end as flows out at the other.

From these remarks the following important laws become self-evident:

As the pressure, and not the electricity, is that which is produced and consumed, it follows that the current strength is always the same in every part of a given circuit. In case the circuit is divided at any point, the sum of the divided currents is always equal to the undivided current in the rest of the circuit. The function, therefore, of an electric machine or battery, is to *generate and maintain an electromotive force*, or electrical pressure. Whenever this pressure is allowed to act or to equalize itself, a *current* of electricity will be produced.

The electrical resistance (measured in ohms) which opposes the current, is also quite analogous to the mechanical resistance which must necessarily be encountered by every current of air. The only difference is that the electrical resistance depends only on the cross section, length, and nature of the material of the conducting medium, while with a current of air the resistance is affected by certain other factors, thus making calculations due to electrical resistance much the more simple of the two.

The laws of resistance are very easy to understand. Electrical resistance increases in the direct ratio of the length and decreases in the ratio of the area of cross section. It also depends specifically upon the nature of the material, or in other words, is a particular constant for each substance. It also increases with the temperature in metals and decreases in carbon and liquids. The unit of resistance now universally adopted is the Paris or legal ohm, which is the resistance of a column of pure mercury of one square millimetre cross section and 106 centimetres in length, at a temperature of 0° C. The Siemens unit is the same except that the column is 1 metre long. The old unit formerly used is called the British Association (B. A.) unit. Their equivalents are as follows:

1 legal ohm	=	1.0112 B. A. units.[1]
1 B. A. unit	=	.9889 legal ohms.[1]
1 Siemens unit	=	.9434 " "
1 legal ohm	=	1.0600 Siemens units

The very simple relation which exists between the electrical pressure or electromotive force, the resistance and the resulting current, forms the basis of almost all electrical computations and is known as Ohm's law. This law is nothing more than a statement of the fact that the result of any action increases when the cause of action increases, and decreases when the force opposing this action increases. As we have seen, the electrical pressure or electromotive force is the cause which produces a current, without which a current cannot possibly exist. We have also seen that the resistance opposes this current, and therefore opposes the action of the pressure, or cause of the current. Therefore the resultant of both of these forces will be the current. Or stated in more concise terms, the resulting current is equal to the electromotive force divided by the resistance.

From this well-known law two others necessarily follow, which are equally useful, though, strange to say, less frequently used. One serves to determine what pressure or electromotive force is required to produce a certain current through a certain resistance. It follows from the law above given that this electromotive force will be the product of the given resistance and the given current. The other enables us to find what resistance is to be inserted in order that a given electromotive force shall produce a certain current. This resistance will be readily seen to be equal to the electromotive force divided by the current.

Another very important law follows from the above-mentioned premises. If a current divides at any point into two or more lesser currents, it follows that each of these divided or fractional currents will be greater in proportion as the resistance of its own circuit is less, or in other words, each current will be proportional to the reciprocal of its resistance. It is also self-evident that the sum of the divided currents will be equal to the total undivided current. If the difference of the electrical pressure or potential, at the points when the current divides and joins again, is known (as in a dynamo machine), the calculation becomes exceedingly simple, as it then is merely a double application of one of the laws above given, namely, that the current in each branch is equal to the difference of potential divided by the resistance of that branch.

The only quantities, besides *time*, which are of the same kind in both electrotechnics and mechanics, are *energy* or *work*, and *power*. These are, therefore, the connecting links between the two, and are the quantities to which both must be reduced, in order to find how much of the one will be equal to a given quantity of the other.

In mechanics it is well known that work is measured in foot-pounds, while power (which is merely an amount of work done in a certain time or rate of doing work) is measured in horse-powers.

If a certain quantity of air, for instance a cubic foot, at ordinary pressure, is compressed, say to half that quantity, or what is the same thing, to double that pressure, a certain definite amount of foot-pounds of energy will be required, and if it be allowed to expand again, that is to equalize the pressure again with the atmosphere, that same amount of work in foot-pounds will be given off. It will be equal to

1. As marked on the standard legal ohms, by Mr. Glazebrooke, secretary of the British Association.

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energy in the bullet would run the watch almost two years. the pounds mean pressure multiplied by the distance through which it acts, in feet.

In precisely the same way, when a certain quantity of electricity in coulombs has its electrical pressure increased a certain number of volts, a certain definite amount of work will be required, which is measured in volt-coulombs. When this same quantity at high pressure is allowed to decrease its pressure again, that same amount of work in volt-coulombs will again be given off, just as in the case of the air.

As in the case of air, if the quantity of electricity be doubled, the work will be doubled, or if the pressure be doubled the work will be doubled; in other words, the work in electrical units will be the number of volts pressure through which it has been raised or through which it has fallen, multiplied by the quantity in coulombs which have been subjected to this change of pressure. The electrical energy is, therefore, merely the number of volts multiplied by the number of coulombs.

The same equality exists between electrical and mechanical power. As a horse-power is merely a certain number of foot-pounds of work done per second, so electrical power is a certain number of volt-coulombs of work done per second. As a coulomb of electricity flowing per second is an ampère of current, it follows that a volt-coulomb of work per second is a volt ampère, or, as it is frequently called, a watt, from which it follows that volt-ampères, or watts, and horse-powers are units of precisely the same kind and may be reduced from one to the other.

In order, therefore, to calculate the electrical power in a circuit, lamp, or machine, it is only necessary to multiply the volts pressure by the ampères of current. This law, combined with Ohm's law, gives two more equally important laws in regard to electrical power. When the electromotive force and the resistance are given, the power in volt-ampères or watts is equal to the square of the electromotive force divided by the resistance; *i. e.*, if with the same electromotive force the resistance is doubled, the power is halved; or if with the same resistance the electromotive force is doubled, the power is increased four times. The other law is that when the current and resistance are given, the power in volt-ampères or watts is equal to the square of the current multiplied by the resistance. That is, if, with the same current, the resistance is doubled, the power is doubled, or if, with the same resistance, the current is doubled, the power is increased four times.

This last law is often stated in a very misleading way in text books and by many scientists, whose lack of clearness in statement is often very annoying to practical engineers. Thus we find it stated that the energy is proportional to the square of the current. This is not only misleading, but in many cases absolutely false. The current may be increased, while the total energy may be the same, or greater, or less, depending on the electromotive force or the resistance. The current itself is no criterion, for it might as well be said that the current of water in a river represents horse-power. If the fall of the water is not taken into account, or in electricity the electromotive force or resistance, the current by itself is no measure of the power developed. It will be readily seen that if the current be doubled by halving the resistance (the electromotive force remaining the same), the energy will be increased twice as much, and not four times. In another case, if the electromotive force be reduced to one-quarter and the resistance reduced to one-eighth, the current would evidently be doubled, while the energy would really be only half as great.

The law just given is correct only in one case, that is, when the resistance remains the same. The power then increases with the square of the current, for in order to double the current in the same resistance, it is necessary to double the electromotive force, thus doubling both volts and ampères, quadruples the volt-ampères.

The so-called absolute system furnishes us with a means of finding the actual quantities of foot-pounds or horse-powers which correspond to a volt-coulomb or volt-ampère. These values are as follows:[2]

1 volt-coulomb	=	.73732 foot-pounds.
1 foot-pound	=	1.3563 volt-coulombs.
1 volt-ampère	=	.0013406 horse-power.
1 horse-power	=	745.941 volt-ampères.

If a pound weight be dropped freely through a distance of 1,000 feet, or if 1,000 pounds be dropped through a distance of 1 foot, the quantity of work will be precisely the same in each case, namely, 1,000 foot-pounds. But at the same time the quality or kind of work will be quite different. Or if in one case a small quantity of air under high pressure, and in another case a large quantity of air under low pressure, be allowed to escape, the actual amount of work done might be the same, yet the quality or kind of work or effect would be quite different. Similarly, if a coulomb of electricity is allowed to change its potential suddenly 1,000 volts, or if 1,000 coulombs be allowed to fall through a potential of one volt, the actual quantity of work in volt-coulombs will also be the same; yet in the two cases the form or quality of the energy dissipated would be quite different. Many electrical phenomena in which electrical energy is dissipated can, therefore, be much more readily understood by comparing them to air under compression, the pressure being proportional to the electrical pressure and the quantity proportional to the quantity of electricity. This will readily answer the question frequently asked, "what is the difference between the electricity of a friction or influence machine, or Rhumkorff coil, or lightning, and that produced by batteries, dynamos, and used in telegraphy, telephony and electric lighting?" The difference is merely in the form or quality of the energy dissipated.

There is also a similarity between the different forms in which power exists. For instance, if a pound weight be dropped freely through a distance of 1,000 feet, or if it be allowed to fall slowly, as when driving a clock; in both cases the work will be the same, but as the time in which it is done in the two cases is quite different, the power will be different. In the same way, if a quantity of elastic gas confined under high pressure be allowed to escape suddenly, as in firing a cannon, or allowed to escape slowly, as in a small compressed air engine, the quantity of work may be the same, yet the kind or quality will be very different. Similarly, if a quantity of electricity at high pressure or electromotive force be allowed to dissipate its energy suddenly, as in a spark or bolt of lightning, or if it be consumed gradually, as in the telegraph or electric light, the quantity in volt-coulombs may be the same, yet the power in volt-ampères will be quite different.

In still another case the power might be the same in the two cases, yet its quality or kind may be very different. For instance, a very high waterfall with small quantity of water, on the one hand, and a sluggishly flowing river with small fall, on the other hand, may each develop precisely the same available horse-power, yet the quality of their power, and therefore the apparatus necessary to effect its conversion, will be quite different. This is analogous to a dynamo of high electromotive force and small current, such as is used for arc lighting, and another of low electromotive force and great current, such as is used for electroplating; they may both require the same horse-power, yet the form of the electrical power is different.

A few quantitative examples, illustrating what has been said above, may be of interest. The pressure of ignited gunpowder being about 40 tons per square inch, the energy in a bullet fired from a small pistol is about 600 foot-pounds. As a pocket watch consumes about one fifty-four millionth of a horse-power, it follows that the amount of

2. For the method of calculating them, and for a complete set of equivalents, see THE ELECTRICIAN, vol. ii., p. 103 (April, 1883).

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As the current in an Edison telephone transmitter was found to be about .0001 ampère,[3] and its resistance about 1 ohm, the energy in it is slightly less than one-thousandth part of that used in a watch, and it would therefore be run over 2,000 years with this same amount of energy as developed in a small pistol.

The charge of a small Leyden jar was found to be .000,008 coulombs at about 50,000 volts. This in discharging would develop .4 volt-coulombs, or .288 foot-pounds of energy, which would run a watch about eight hours, and is about equal to double the amount of energy consumed per second in the line of a telegraph circuit of 100 miles.

Several authorities have calculated the electromotive force of a bolt of lightning to be about 3,500,000 volts, and the current to be about 14,000,000 ampères, the time of the bolt being measured to be one twenty-thousandth of a second. A simple calculation shows that this amount of energy set free in that short time is about as much as that of a 100 horse-power engine for almost 10 hours.

Besides the electrical units above mentioned, there are certain others less frequently used.

Capacity in electrotechnics is very similar to capacity in mechanics. Although it cannot be measured in cubic inches or quarts, yet its function, which is to measure quantity, is the same as in the ordinary sense. Just as a quart measure may hold a certain amount of air at atmospheric pressure, or double that amount (by weight) at two atmospheres, and so on, so does an electrical condenser, having a certain electrical capacity, hold a certain definite amount of electricity at a certain electrical pressure or electromotive force, and double this amount at double the pressure, and so on. Any amount of electricity can be forced into a condenser of a given capacity by increasing the pressure in proportion, in the same way that any quantity of air (by weight) can be forced into a quart measure by simply increasing the pressure accordingly.

From this the law in regard to capacity becomes self-evident. The quantity of electricity in coulombs in a given condenser, divided by its pressure in volts, is always a constant, and is equal to the capacity of the condenser in *farads* or units of capacity.

Two other laws follow from this, namely, that the quantity of electricity in a condenser is the capacity multiplied by the pressure or electromotive force. And lastly, the pressure or electromotive force of the electricity in a condenser is equal to the quantity of electricity divided by the capacity of the condenser.

Ampère-hour is a convenient term for representing 3,600 coulombs, as it is equal to an ampère flowing for one hour, and is used in connection with the accumulation of electrical power in batteries.

Ampère-winding or ampère-turn, used in reference to electro magnets and solenoids, represents an ampère of current circulating once around the coil. The number of windings or turns of wire in a coil, multiplied by the current in the wire, gives the number of ampère-turns of the whole coil. As will be seen hereafter, it is a term used for representing, measuring and calculating the magnetism of machine magnets.

Electrical horse-power is merely the number of volt-ampères which equal a mechanical horse-power, as given above in the table.

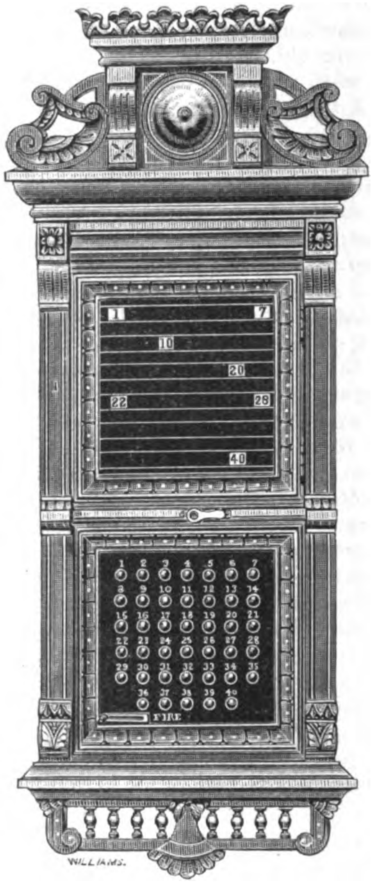
(*To be continued.*)

IMPROVED HOTEL ANNUNCIATOR.

The importance of communication between the rooms of a hotel and the office, led to the early introduction of electrical annunciators for that purpose, which have been improved from time to time, with a view to making them not only more reliable, but more comprehensive in their operations.

The convenience of ascertaining if a guest is in his room, or, what is of still greater importance, communication with each apartment in case of fire, has suggested the Hess guest call and fire alarm which, as combined with the gravity drop annunciator, is shown in the cut below.

Each room is supplied with a bell in addition to the ordinary push-button and is connected with a knob corresponding with its number as in the lower half of the case. In reply to a stroke on the bell, the guest signals to



The Hess Guest Call and Fire Alarm.

the office by pushing his button in the usual manner. By the simple movement of a lever in the lower left-hand corner of the case, every bell in the house may be rung simultaneously, and all inmates aroused in case of fire or other immediate danger. It is obvious that such a method of calling guests is preferable in every respect to the provincial practices which prevail in most hotels, and there can be no reasonable objection to its general introduction. It is manufactured in various styles by the Standard Electrical Works of Cincinnati.

THE DYNAMO AS A GENERATOR AND AS A MOTOR—SOME ANALOGIES AND CONTRASTS.[1]

During the last few years an immense amount of attention has been given to everything relating to the theory and practice of dynamo machines. So thorough has been the study of the problems connected with these machines, which are of a character to appeal both to the physicist and the practical constructor or engineer, that it is now not difficult to lay down, in a fairly complete form, the laws governing their action, and the rules and principles under which they should be constructed; although three or four years ago much confusion and uncertainty existed as to what was best in dynamo construction.

But in electric motors the case is very different. While it is easy to name physicists and constructors in considerable numbers who hold clear and correct views on the subject of electric generators, it is by no means easy to find

3. See Electrician and Electrical Engineer, November, 1885, vol. iv., p. 422.

1. From a paper by W. M. Mordey, in the *Philosophical Magazine.*

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definite and correct explanations of what is right and what wrong in regard to the allied subject of electric motors.

And on no point does there appear to be greater uncertainty than on that of the analogies and the difference between the two machines. For instance, while it has been proved beyond question that in dynamos the most economical and best working conditions are obtained by employing field magnets of great magnetic strength, and armatures which are relatively very weak magnetically, the only definite assertion within the writer's knowledge given with authority on this point asserts exactly the contrary to be the case with motors—viz., that the fields should be relatively much lighter and weaker than the armatures.

Again, what can be more striking than the great and known difference between dynamos and motors in respect to the very important matter of efficiency. Almost any modern generator will give a return in the form of electric energy of 90 per cent. of the mechanical energy expended in it, and a useful yield of over 80 per cent. in its external circuit. In the case of the best generators this is a considerable understatement of the working conditions. With electric motors, on the other hand, one has to be contented with a much lower efficiency. The energy supplied to them is severely taxed in the process of conversion. Motors frequently yield, as mechanical energy in a useful and available form, only 30 per cent., and seldom more than 60 per cent., of the electric energy absorbed.

The reversibility of the dynamo, or its ability to work either as generator or motor, has been spoken of as one of the most important discoveries of late years (the great physicist credited with the expression of this opinion having apparently overlooked the fact that Pacinotti made his famous machine as a motor in the first place). But the fact that a given machine which will work well and efficiently as a dynamo will not work so economically when its action is reversed and it is made to act as a motor, is a proof that the reversal is accompanied by some radical change in its action. This difference, where it is noticed at all, is generally sought to be explained by an assertion or a supposition that, having been designed and made for one purpose, it was therefore not suitable for the other. No satisfactory explanation, as far as the writer is aware, has been given of the cause of this lower efficiency of motors, or, in other words, of how the missing power is expended. In what particulars a good motor should resemble a good dynamo, and in what they should differ from one another, are also interesting questions of great importance which await answers.

The writer having, with Mr. C. Watson—who is his assistant in the works of the Anglo-American Brush Electric Light Corporation—given some attention to the matter from a practical point of view, a great necessity was felt for some foundation on which to work, similar in character to the broad general principles which serve to guide the practical constructor of dynamo machines. In the search for such general principles, all those ways of considering the actions which depend on the idea of magnetic poles in the armature were abandoned, and the conclusion was arrived at that the armature should have no polar action whatever, that the iron of the armature should have only the function of a conductor of lines of force, and that the power of the motor should be due to the simple action between the lines of force of the magnetic field and the armature wires conveying currents at right angles to those lines of force. This mode of regarding motor action is convenient on several grounds, and leads to certain conclusions which, if correct, form substantial bases for practical construction. Thus the armature, instead of being, as hitherto, considered as a strong electro-magnet placed in the field of another electro-magnet, is to have its electromagnetic functions reduced as much as possible, or preferably suppressed altogether.

The field is to be very strong.

As with such an arrangement there is no polar effect in the armature except that due to the direct magnetic induction of the field-magnets, it follows that the maximum power is obtained with any given current when the brushes occupy an absolutely neutral position, or, in other words, when there is no "lead" and no distortion or rotation of the field. These conditions do away with the most troublesome and prolific cause of the sparking at the brushes, which is so often an objectionable feature of most electric motors.

But by working backwards in this way it was seen at once that the conditions which seemed to be best for a motor were precisely those which the would-be designer of a perfect dynamo would set before him as his goal.

Certain perfect analogies had been arrived at. In both dynamos and motors, according to this briefly sketched view:—

1. The field should be a very strong, the armature a very weak electro-magnet.

2. In both generators and motors "lead," distortion, or displacement of brushes or of magnetic field is wrong, and is to be avoided by attention to 1.

Whatever "lead" there may be in either case, there is this difference, that in dynamos this "lead" is in the direction of rotation; in motors it is in the opposite direction, as the course of the current through the armature is reversed, but the field is the same.

3. In both generators and motors absence of sparking at the brushes depends mainly on the conditions of 1 being complied with.

4. Reversal of rotation. In neither generators nor motors is movement of the brushes necessary.

But having got so far, a little consideration suggested the probable existence of another analogy. Since a dynamo having the above theoretically perfect form and action with a constant field would produce a constant electromotive force if run at a constant speed, independently of the load or amount of current generated, a motor constructed on the same principles and having a constant field, if supplied with energy at a constant difference of potential, should run at a constant speed, independently of load.

If this should prove to be a true analogy, a simple means of obtaining results of great use in the practical application of electricity would be obtained—results which have been sought in many directions, more or less complicated, without any great success.

By permission of the Anglo-American Brush Electrical Light Corporation experiments were carried out in the testing-room of their works with a "Victoria" dynamo. The results ultimately obtained show that this fifth analogy is as true as the preceding ones, a constancy of speed being obtained which was very remarkable, even when the load was increased, until much more than that which as a generator was usually considered the full working current was traversing the armature.

At first it appeared that the counter electromotive force of the motor was dependent neither on speed nor strength of field, as the latter was constant and the former very nearly so, while the current rose with the work; but calculation showed that this was not the case—indeed it could not be so.

Let us call the counter electromotive force e, and the loss of potential caused by the resistance of the armature e_1, and the difference of potential at the terminals E. Then

$$e + e_1 = E.$$

Calling the current C, and the resistance of the armature R, we know that

$$e_1 = CR;$$

The resistance of the armature of the motor in question was .027 ohm, which we will call .03 in order to make some allowance for the effect of heating.

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In the first and last readings of the second set of tests we have, therefore, the following conditions :

Speed.	e_1.	e.
680	.87	99.13
660	3.75	96.25

Now $\frac{680 \times 96.25}{660} = 99.13.$

From which it appears that the counter electromotive force was exactly proportioned to the speed, as is to be expected where the field is constant and the magnetic distortion *nil.*

The other cases do not work out with the same accuracy. The results are, however, quite within the limits of error inseparable from the rather rough conditions of these workshop tests.

One other fact may be pointed out in connection with these tables of results and curves. In the case of dynamos working with a constant field, the output with the same current is almost exactly proportional to speed, as the E. M. F. is also simply proportional to speed. So, with the motor, the speed is proportional to the E. M. F. of supply ; and the work, with the same current in the two cases, is simply proportional to speed, therefore to E. M. F.

With regard to the theory alluded to above, that in a motor the fields should be much weaker and lighter than the armature, it may be pointed out that in this, as in the other points mentioned, there is a real analogy between motors and generators, inasmuch as, according to the views briefly expressed in this note, such a motor, although a bad one from most points of view, would have a certain advantage in that for its weight it would do a good deal of work. Similarly, dynamos may be, and have been, built which, although far from efficient and reliable, will give a large output for their weight. Their construction is, however, scarcely to be recommended on this ground, except, perhaps, under very exceptional circumstances ; and they, as well as the motors constructed on the same lines, appear to be instances of a mistaken apprehension of elementary principles.

Having briefly traced the analogies between generators and motors thus far, the subject may be dismissed for the present with the remark that a further consideration of the matter serves only to reveal the fact that in almost every phase of their actions the two machines afford further opportunities of a direct comparison.

Turning now to the question of efficiency alluded to above, it is evident that there is some important cause of loss or waste of energy in electric motors which is absent in generators. This has always been a kind of *lacuna* in the explanations of the action of motors ; and in order to localize the loss and to ascertain its cause, the several possible sources of waste were carefully considered. These are :—(*a*) Friction at the bearings, air-friction, and friction of the brushes against the commutator. (*b*) Loss of energy in heating the armature and field-conductors, and a certain loss due to self-induction. (*c*) Loss by the production of eddy-currents in the iron.

Now it is evident, especially with a generator or motor having the qualities sketched above, that at the same speed and working with the same currents in its conductors, the losses under (*a*) and (*b*) must be identical, whether it be working as a generator or as a motor. And as with such conditions its efficiency as a motor is lower than as a generator, the cause of the loss must be sought under (*c*)—*i. e.*, the eddy-currents in a dynamo must be less than in a motor, all other conditions being the same. And such is the case, the explanation arrived at by the writer and by Mr. Watson being a very simple one.

In a dynamo the rotation of the armature causes eddy-currents to be generated in the iron core, in the same direction as in the conductor proper with which the core is surrounded. Of course, as the armature is always more or less subdivided or laminated in a direction at right angles to the lines of force, any circulation of currents round the core is avoided ; but local currents, which are aptly called eddies, are set up, and, taken as a whole, these eddy-currents on the outside of the core are in the same direction as the current flowing in the copper conductors.

In an electric motor, however, the eddy-currents and the currents in the copper conductor are in opposite directions; as, although the E. M. F. set up in the conductor is in the same direction in a motor as in a dynamo, the current in the former is forced through the armature in a direction contrary to the E. M. F., or opposite to its course in a generator. According to the laws of induction, therefore, it will be seen that while in a dynamo the two sets of currents, those in the iron and those in the conductor, tend to oppose and to reduce one another, in a motor they act in such a manner as to mutually assist each other. Thus, with the strength of field, the current in the conductor, and the speed the same in the two cases, it will be seen that in a motor the eddy-currents in the iron core of the armatures will be greater than in a generator, and therefore the heat loss in the former will be more than in the latter. There is little doubt that this is the cause of the lower efficiency of motors than of generators ; and it points to the advisability of giving even greater attention in the former to those principles which are well understood for the reduction or elimination of eddy-currents.

DIAMETERS OF AMERICAN GAUGE NUMBERS.

BY CARL HERING.

In practice it is often very convenient to designate certain definite sizes of wire by arbitrary numbers, as is done in the wire gauges, but in certain cases it is, on the other hand, very inconvenient, as it necessitates the use of a table of equivalents of the diameters corresponding to the arbitrary numbers. If this table should not be at hand at the time when needed, the engineer is at a loss how to determine the diameter, unless he happens to remember it, or has a wire at hand to measure it. Another case in which the use of gauge numbers is inconvenient is when, in certain formulae, such as those for the winding of magnets for machines, it is desirable to obtain the size of the wire in gauge numbers directly, instead of in decimals of inches.

In connection with the latter the writer has deduced by the use of analytical geometry, a certain relation between the numbers of the gauge and the corresponding diameters, so that without any table of equivalents the diameters of any gauge number could be readily calculated, and for any given diameter the gauge number could be determined.

To deduce this relation for the American or B. & S. wire gauge, the diameters and the corresponding gauge numbers were plotted on cross section paper and a curve drawn through them. This curve was quite a regular one and not a broken one as in the British gauge, showing that there existed a regular law or equation between the diameters and the gauge numbers. This relation was then determined and was found to be as follows, assuming the values for the diameter as given in the many tables published as being correct.

Letting d be the diameter in mils or thousandths of an inch, and representing the gauge number by n, the equation or relation between them was found to be as follows:

$$d = \frac{a}{b^n}$$

in which a and b are constants.

Unfortunately this is an exponential equation and is very awkward to use in practice in that form. As every engineer understands the use of logarithms and has a table of

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them at hand, the equation may be reduced to the following convenient forms:

$$\log d = c - d\,n$$
$$n = e - f \log d$$

in which form they can be used readily, and can be introduced into other equations, such as those for calculating resistances or for winding magnets.

For quite a large number of sizes the values of the constants were determined and were found to be very nearly the same, showing the assumption of the equation to be correct or very nearly so.

The mean values obtained and introduced in the equations are as follows:

$$\log d = 2.51170 - 0.050355\, n$$
$$n = 49.879 - 19.859 \log d$$

As most calculations in which this would be used have reference to resistances, which are rarely absolutely correct, the following simple forms, giving approximate values, are in most cases sufficient;

$$\log d = 2.5 - 0.05\, n$$
$$n = 50. - 20 \log d$$

The gauge numbers for the largest sizes being zeros, can never be obtained in the form of equations, and have, naturally, to be represented by the values no. 0 = 0; no. 00 = — 1; no. 000 = — 2; no. 0000 = — 3. If the equation gives — 4 as an answer, it simply means that the diameter is larger than that of no. 0000, and that it is the next size larger than no. 0000, if such a size were made.

To take an example, what is the gauge number of a wire $\frac{1}{4}$ inch = 250 mils, in diameter?

$$n = 50 - 20 \log 250 = 2.04 = \text{No. } 2,$$

or a little smaller than No. 2.

What is the diameter of No. 6 wire?

$$\log d = 2.5 - 0.05 \times 6$$
$$d = \text{about } 160 \text{ mils.}$$

To show its introduction into other equations, take the value for the resistance in legal ohms of good commercial copper wire at about 60° F.

$$R = 10.\frac{L}{d^2}$$

in which L is the length in feet and d the diameter in mils. Introducing our value for d and reducing, gives

$$R = .0001\, L\, 10^{\frac{n}{10}}$$

But as this is not a convenient form, it may be reduced to the approximate form

$$R = .0001 \frac{L}{.8^n}$$

showing a rather curious relation between the resistance of a wire and its gauge number, n.

This may be used in practice for the larger sizes up to about Nos. 10 to 15; over that it gives too low results.

THE TELEPHONE SUIT.[1]

The long delay which has attended the preparation of the bill of complaint of the government against Bell, will surprise no one who has in mind the difficulties of the problem with which counsel have had to deal. It was quite evident that the original bill prepared by the Pan-Electric company was never intended to come before the courts upon its merits, being gotten up merely to afford the attorney-general an excuse for commencing suit. If the synopsis which first appeared in the Washington *Post* is, as we suppose, a careful preparation by competent hands, the new bill is a much stronger document than the original one, and has avoided most of the absurdities and inconsistencies of the other. But the effect of this added strength is to bring out in a clearer light than ever the absence of all sound reason for commencing the suit.

1. *The Evening Post*, New York.

We have no desire to anticipate in any way the final verdict of the court. When we consider how many informalities may invalidate a patent, how the extreme freedom with which our government issues patents is set off by laws giving every possible advantage to parties contesting them, how numerous the competitors, and how great the reward of overthrowing the Bell patent, we cannot but regard the unbroken series of decisions in its favor as a marvel. It would be hazardous to claim that no loophole in the document and no invalidating circumstances in its issue could be brought to light by the searching inquiry now to be instituted. The point we wish to bring to the attention of our readers is, that the bill makes a number of statements which, if true, show that the action taken by the government is quite unjustifiable, and the expense caused by it a flagrant waste of the public money.

For example, it is averred that Bell purposely framed his application and claim in general and ambiguous terms in order to cover both antecedent and future inventions, and to deceive and mislead the examiners of the patent office and the public. Now, if Bell did this, and if it was a fraud, then the fraud was practiced on no other person than Bell himself. For the statutes of the United States clearly provide that if a patentee does this, any citizen of the United States may use the invention at his pleasure; and if Bell is so imprudent as to bring suit against him on his patent, the citizen can not only secure a verdict, but make Bell pay the costs of the suit. What excuse, then, can the government have for going into court with such a plea? The bill also states that on March 10, 1876, Bell obtained a patent for a telephone in which the transmission of speech was obtained by a liquid transmitter or water telephone described in Gray's caveat, which had been filed three weeks before. Now, Gray's caveat has been before the courts and the public for many years, as well as Bell's patent. A patent by Bell for anything contained in Gray's caveat is not worth the paper it is printed upon. What possible excuse, then, has the government for going to such expense in annulling the patent? The proceedings are very much as if the government should be asked to expend several thousand dollars in erecting machinery to remove an objectionable building, on the motion of parties who averred that the building was only a fog-bank which would be carried away by the first breeze.

Our readers will be interested in knowing what the complainant now says about the state of Bell's knowledge of telephonic transmission during the critical period under consideration. We have alluded to the claim of the Pan-Electric company, that Bell well knew his apparatus to be a speaking telephone, but cunningly and wrongfully withheld that knowledge from the examiner of the patent office. We have also discussed the claim of another party that he did not discover his apparatus to be a speaking telephone until some time later. On this critical point we find that the government counsel sweep away both hypotheses by claiming that the apparatus was not a telephone at all, and "lacked in description or drawings any machine then, or at any time, capable of transmitting speech." Here again we find a remarkable silence on the burning question why the government should spend money in invalidating a patent for such a cumbrous and worthless piece of apparatus. It is curious to see the same fallacy coming in from beginning to end of the paper. It again calls the attention of the court to what has been considered the great fact justifying the suit, namely, that only the government and not a private citizen can bring suit to repeal a patent. It ignores in the most extraordinary way the fact that the laws make ample provision against any necessity for such repeal, by legislation which protects every person against a suit for infringing a patent which there is any grounds for repealing.

We have looked in vain through the document for any allusion to the supposed fraudulent alteration of Bell's application by the addition of new matter. As this fraudu-

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lent proceeding is one which the patent office and its clients have been engaged in every week of its existence, we apprehend that the proper formulation of the complaint in this case must have caused some embarrassment to counsel, and that the matter was dropped in consequence.

ABSTRACTS AND EXTRACTS.

THE INCANDESCENT LAMP FOR PHOTOGRAPHERS.

In its notes from abroad the *Photographic Times* points out the difficulties in obtaining a satisfactory light for exhibitions as follows:

The great trouble with lantern exhibitors lies with the light. Those who project their pictures on a large scale, and to hundreds of spectators, have assistants who relieve them of much of the trouble and concern attendant upon such exhibitions. But it is different with the private photographer, who aims merely at exhibiting his productions to the members of his family, or, perchance, a dozen of friends invited for the purpose. To such an one the obtaining of a brilliant light which can be easily managed is a matter of great consideration. A lime light involves previous preparation and a greater degree of care throughout than many like to undertake. Lighting by oil is, of course, very simple; but while the light is not all that is desired, the heat and smell are too often extremely offensive. It is to the electric light that aspirations are now being most directed. Much has of late been promised in this connection, and for many months past we have been expecting every day to hear of the last obstacle having been overcome. We have a strong belief that the efforts now being directed to the securing of this boon will soon be crowned with success.

What is required is an electric light, with an incandescent burner, which, when excited by a *portable battery*, shall emit a light in the vicinity of from sixty to a hundred candle-power. In New York we have reason to believe that this is on the verge of fulfilment, while the same can be said of London. We lately spent an evening in company with Mr. J. W. Swan, whose name is so intimately associated with the invention of the incandescent electric lamp, and urged him to direct his attention to this special requirement for photographers. While in his experimental workshop we saw innumerable forms of lamps excited by batteries of various kinds, some of which emitted lights that seemed as if they would quite well serve the desired purpose. The solution of the problem is to engage the attention of this skilled photographic chemist and electrician.

In connection with this topic, an incident occurred at the opening soirée of the Camera Club a few days ago. Mr. Dresser, the honorary secretary, who exhibited a number of transparencies on the occasion referred to, said it was his intention to have exhibited that evening his own lantern, which was fitted with an incandescent light given by a small battery. It had, he said, been in successful operation in his own residence, but owing to the sudden illness of a workman to whom he had entrusted the lantern the previous day for a slight alteration, it could not then be exhibited, although it would certainly be so at their next meeting. Mr. Dresser informed us that the power of the light, while considerably below that of the calcium light, was somewhat in excess of that obtained from the best of oil lamps. This is pleasant news. We are soon to be afforded an opportunity of seeing the apparatus, and will lose no time in describing it for the benefit of the many readers whose aspirations are in this direction.

RUSSIAN EXPERIENCE WITH ELECTRIC HEAD-LIGHTS.

Some time ago electric lamps were fitted to the locomotives running on the Nichols railway, extending from St. Petersburg to Moscow. For awhile, says *Engineering*, they appeared to give satisfaction; but at length the staff commenced to complain of them, and now, after an investigation by the directors, they have been totally discontinued. The lamps were powerful, throwing a stream of light a mile ahead of the train, and so far as the illumination of the railway track was concerned, the locomotive drivers and guards admitted their utility. Their objection to them was, however, that the contrast between the lighted space and the darkness on either side was so acute that it annoyed the eyesight, and in some cases, after a time, incapacitated the drivers altogether. Medical evidence was adduced by the company's doctors, proving that in one or two instances the vision had been so injured as to provoke fears of blindness. Although the electric lamps have been removed from the locomotives, the directors have not abandoned their intention of illuminating the line more liberally than is commonly the case. Two schemes have already been mooted, one for lighting the railway track for a distance of a mile each side of the station by means of suspended electric lights, and another for lighting the railway in a similar manner throughout its extent from Moscow to St. Petersburg. As very few accidents occur on the railway, owing to the slowness and the limited character of the traffic, it is not obvious that the gain would, in the latter case, be commensurate with the expense, especially as the decadence of nihilism renders extra precautions unnecessary.

A NEW MOTOR FOR VESSELS.

A correspondent, who signs himself "Engineer," is anxious that we should inquire into the merits of a new vessel recently launched in Brooklyn, which is to be equipped with motive power, according to one of our flaming daily newspaper accounts, as follows:

In the centre of the Eureka is a small coal boiler which furnishes the motive power for two air pumps or air compressors placed just abaft it. This boiler will also run a small dynamo engine which is to generate the electricity, which is really the prime mover. Above the four ports or orifices in the boat, and communicating with them by valves, is placed a steel globe two feet in diameter, into which the air is compressed. Into these globes a spray of petroleum is forced and an electric spark causes the explosion through two of the orifices—either the two leading aft or the two leading forward—which will exercise a thrusting force of fifteen tons on either side of the vessel, and these, it is said, may be regulated from two to sixty a minute.

We can assure our anxious correspondent that we shall not fail to observe the performances of the new nautical motor, but before becoming enthusiastic, we think it best to wait and see whether the new motor is really going to "mote," or whether the formation of a big stock company is all that lies behind the glowing accounts published by the daily press.—*American Machinist.*

TELEGRAPHS IN CHINA.

A correspondent writes from Shanghai, under date September 18: "Telegraphing in China has recently made very important strides. The central government at Pekin has, during the last conflict with France, had numerous opportunities of appreciating the importance of the telegraph system. By this agency the central government was enabled to keep up direct communication with its armies in Tonkin, although the distance from Pekin to the seat of war was as great as between London and Cairo, and through the telegraph it could negotiate direct with the French government. This has made a great impression upon the Chinese government, who are taking active measures for the extension of the telegraphic system to all parts of the empire. An idea of what this means and what work it will necessitate will be understood when it is remembered that the Chinese empire, both in area and number of inhabitants, exceeds Europe. Mr. Henrik Bohr, a native of Copenhagen, has recently been appointed chief superintendent in all affairs telegraphical."

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CORRESPONDENCE.

NEW YORK CITY AND VICINITY.

Incandescent Lighting an Established Modern Improvement.—The Subway Commission Still Anxious to be Right Before They Go Ahead.—The Aldermen Labor to Secure Electric Street Lighting.—A Mechanical Telephone Exchange.—The Improved Ticker Service.—A New Home for the Telephone Company.—The Edison Machine Company Going to Brooklyn.—Another Levy on Western Union Property.—An Establishment for Electrical Investigation.

EVERY new building erected, or every old building refitted, gives evidence of the eternal march of improvement. It being the fact that the most imposing office buildings erected are fitted with incandescent lighting fixtures, is very satisfactory proof that it is considered the best form of artificial illumination. There is no doubt that there is a demand for a light of this character in all cities and towns of any importance, and constant experience is increasing the possibility of its coming into still more general use. A little observation as one passes along the principal streets, will soon convince one that incandescent lighting is growing in popularity, and would doubtless be more common if it could be more readily introduced.

No satisfactory report of the possible decision of the Subway commission has yet been made public. There is an apparent desire on the part of each member of the commission to do the very best, but in deciding which is the best out of various plans is the problem which confronts these gentlemen. Even if united upon the question as to the particular manner of construction, a second question arises as to the nature of the material to be used, and it is upon this to a great extent that the action of commission is now hinging. Owing to the very serious illness of Mr. Charles E. Loew, president of the commission, all official action has been suspended until his recovery. Meanwhile spring is upon us, and several of the companies are very anxious that some decision should be arrived at for they are now debarred from undertaking any new construction on their own account, either above or below ground. It is necessary that some provision should be made for the extension of the arc lighting service, and it is just here that the ludicrous condition of affairs is most apparent.

Public street lighting by electricity is very popular. The lighting of one street is like buying an elegant piece of furniture for a house. Everything else becomes shabby by comparison, eventually rendering necessary the entire refurnishing of a house. A single street lighted with arc lamps, makes the others conspicuous by their darkness. It so happens, therefore, that in those wards where the population is most dense, that the aldermen are continually importuned to secure electric street lighting for the benefit of constituents or prepare for defeat at the next election. The necessary legislation granted however, it is still another matter to secure the introduction of the service, on account of the prohibitory underground enactments. Overhead wires must now be strung along the roofs of friendly property holders, or else smuggled through the streets under the guise of repairs. To introduce street lamps however, we must have posts for that purpose, and the style of electric lamp posts used in this city is admirably adapted for supporting wires.

The Consolidated Telephone Co., which has for some time been engaged in the rental of mechanical telephones, is now about exploiting the business of mechanical telephone exchanges. A central office of this character is being fitted up at 171 Greenwich street, while similar enterprises are being undertaken in other cities, where there is supposed to be a field for such a service. The manner in which such wires would be accommodated in a subway system is not apparent, and as they are not electrical would possibly not be considered, were it not for the clause to the effect that *all wires wherever found above ground* were to be included in the final entombment. There is certainly a field for mechanical telephones in the country, but the conditions existing in a city like New York for instance, are more exacting. They are not. however, insurmountable, and if legal complications are avoided, and the tariff based on an equitable footing, there may be plenty of room for exchanges of this character.

All of the down-town subscribers to the ticker service of the Gold and Stock Telegraph Co., have now been supplied with the new Scott printers. Some of the weak points of the system, which are always present at its original installation, have been removed, and the service is now quite satisfactory. The speed of this machine and its rival operated by the Commercial Telegram Co., are so nearly equal, that the relative rapidity of transmission depends more upon the skill of the operator than was formerly the case.

The Metropolitan Telephone and Telegraph Co. has decided to erect an eight story fire-proof building on the north side of Courtlandt street, occupying numbers 16 to 20. The selection of the location is evidently judicious, and as the structure will contain a large number of offices for rental purposes, it will doubtless become the headquarters of the many minor electrical interests which already exist and are continually springing up in this city. The fact that electrical companies are gradually becoming owners of real estate rather than lessees, proves that the business is now of a more permanent character, and in this way the annoyance and expense of moving is lessened.

The Edison Machine Co., at present located in Goerck street, will remove all its plant to Brooklyn, some time during the present year. The company has purchased a square block of ground in the eastern district, bounded by North Tenth, North Eleventh, Third and Fourth streets, for which $45,000 was paid. The plans for the factory which it is proposed to build, have not yet been drawn, though the general idea of its proportions has been sketched. It will be a brick building, four or five stories in height, and will face on each of the four streets, with a court-yard in the centre. The cost of the building is estimated at $125,000. In addition to the plot mentioned, six lots have been purchased on the opposite side of Third street. Here it is proposed to erect the foundry where the rough castings for the heavier machinery will be made. The cost of these six lots was $9,000, and to erect the foundry will probably require twice as much more.

Under-sheriff Sexton levied on the property of the Western Union company, March 7, pursuant to a judgment obtained by J. H. Goodsell, formerly president of the National Press Association, in a suit for damages ocasioned by a breach of contract. The difficulty was adjusted by the company giving a bond in the names of Russell Sage and Jay Gould for the amount of the claim. A stay of execution for six days was obtained pending an appeal.

A movement is on foot looking to the establishment in this city of a laboratory devoted especially to the testing of various electrical appliances, and offering facilities for scientific electrical investigation. For several years people who have had experience in this line have responded to many calls to run in and look at a certain new device which is to revolutionize all existing electrical methods. It is very frequently the case that such investigations require the expenditure of considerable time, in order to give a satisfactory opinion. In the case of dynamos, lamps, etc., it is also necessary to have the requisite power, instruments and mechanical facilities to attain results with scientific accuracy. There is certainly a legitimate demand for an establishment of this kind, but whether that demand is backed by a sufficient amount of money to support such an industry is perhaps a little doubtful.

NEW YORK, March 25, 1886.

BOSTON.

Damage to Wires by the Recent Gale.—Effect of the Indiana Telephone Decision.—What the Managers of the Bell Company Say.—Hearings Before the Legislative Committees.—Inquiring into Electric Railway Working.

OUR overhead wires have experienced their annual shaking up since my last letter. We have had fair samples of western weather, in the shape of blizzards and floods. As far as the wires are concerned the climax for New England occurred on the night of the 25th of February. In Boston the high winds, coupled with the snow, served to place a considerable strain on the telegraph and telephone wires and posts. This strain was so severe in the vicinity of Albany street that one of the poles broke near the top; but luckily the piece did not fall to the ground, but, supported by the wires and partly resting against the top of a building, it remained in the air. The dislocation of the cross-arms of this pole, however, had the same effect as the last straw on the camel's back, for it tended to tighten the wires along Albany street as far as the corner of Oak street, and weaken the already overburdened poles between those points, all of which—seven in number—soon afterward fell with a crash sufficiently loud to startle everybody in the vicinity. An investigation by the police showed that no person had been injured. This fact, considering how much the street is frequented, is remarkable. As has been stated, seven poles were broken, all of which are on Albany street. The first one, or that near the corner of Beach street, was split near the top. The next one, which stood about 60 feet away, literally was broken in three different pieces. The base of the pole in this, as in all other cases, remained rooted to the ground, but the top, bearing the cross-arms to which are attached the wires, fell over toward the middle of the street and there remained dangling in the air. Another pole, near the corner of Kneeland street, was served in somewhat the same manner. Between Kneeland and Oak streets the condition of Albany street was the worst. Four poles had been broken, and the cross-arms, still having the wires attached, had fallen to the street. On each pole there were eight arms, which, combined, bore 124 wires, together with a small cable made of 100 wires. These 124 wires covered nearly the entire width of the street.

The breaking of the telephone company's poles on Albany street greatly incommoded the Western Union Telegraph Co., as all of the company's wires to New York were damaged. The wires, however, were very quickly repaired.

The New England Telephone Co. suffers no damage aside from that done by the wind and storm on Albany street in Boston.

In Portland, Maine, the wires were very much under the weather, and considerable expense was incurred thereby.

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Telephone matters have been and are uppermost in the electrical mind. The Indiana decision had a depressing effect on the main company's stock, and put it down to lower figures than for two years. When some good fellows quietly circulated a story to the effect that "confidentially, you know, we don't believe that that government case will ever be tried; Mr. Goode has a black eye, and the administration will let the case die with him," —and the stock came up 10 or 15 points.

I give the following as the result of a newspaper interview of Bell officials:

"Mr. J. E. Hudson, general manager of the American Bell Telephone Co., and General E. Sherwin of the New England Telephone and Telegraph Co., were seen yesterday at the office of the first named company by a *Post* reporter. In answer to a query regarding the significance of the law recently passed in Indiana restricting the rates of telephone rental to $3 per month, and confirmed by the supreme court of that state, it was agreed by those gentlemen that nothing could be said as yet regarding the probable action of the Indianapolis company in the matter, its future course being now under consideration. It is quite probable, however, that an appeal from the state superior court will be taken to the superior court of the United States at Washington. The chief point urged by the telephone company in objection to the law, which objection will doubtless be shared by all similar companies, is that the sum of $36 per annum is insufficient for the bare expense of putting in and maintaining a telephone. Especially in the case of an exchange of the size of that at Indianapolis, with 1,000 subscribers, the actual cost is considerably more than that sum, and in the case of exchanges in small cities, towns and villages, the expense greatly exceeds that sum.

"An impression prevails in the popular mind," said General Sherwin, "that the business of telephone companies is remarkably remunerative. This impression doubtless arose from the inexperience of the companies in the early days of the business. It has been found by experience that a telephone plant deteriorates 10 per cent. in a year. The entire plant requires renewal, therefore, every ten years. The wires last only half that time. At the expiration of five years wires are so completely eaten through with rust as to leave a bare thread of metal remaining. Then all the apparatus requires comparatively frequent renewal, both on account of natural wear and tear, improvements in switch boards and other apparatus, and extraordinary casualties, such as sleet and thunder storms. A sleet storm is most dreaded by us, because of the large breakage of wires which ensues on account of loading with ice. A sleet storm means the loss of several thousand dollars to our company alone. The last one cost us $15,000 in renewal of wires alone. In a large exchange like that of Boston, the average cost of maintaining a single instrument is much more than the sum fixed by the Indiana law. It is probable that the law was not thoroughly considered and all the facts ascertained before its passage. The legal aspects of the passage of such a law are interesting, and doubtless many would like to obtain the passage of a similar law regulating the price of flour or house rent. It is difficult to predict what course the Indianapolis company will take. Even if the law should be repealed, it cannot be done for a year, and action of the supreme court at Washington would doubtless be even slower. The law is equally unfortunate for the company and for its subscribers."

The Massachusetts legislative committees have been busy with hearings on electrical matters—first, on taxing telephone companies; second, on underground wires; and third, upon repealing of the authority of the American Bell Telephone to hold above 30 per cent. of the capital stock of sub-companies. These hearings are egged on by such little kindnesses as the following: At a meeting of telephone users held at Lowell, Friday evening, Feb. 20th, the following resolutions were adopted:

Resolved, That we protest against the present scale of charges for telephone service, as made by the New England Telephone Co., under the management of the American Bell company, which they claim to be necessary to pay dividends on the stock, watered in defiance of the laws of the commonwealth, and that we request our representatives in both branches of the legislature to do all in their power to promote such legislation as shall limit by law the price which this common carrier shall be allowed to charge us for service.

Resolved, That this meeting shall appoint a committee to attend the hearing, and to be empowered to appear by counsel if they see fit; also that a copy of these resolutions be sent to each of our representatives and senators, and that they be requested to vote for all amendments to our tax levy laws which shall tend to force this monopoly to pay a fair amount of taxes, which it now escapes.

The committee on street railways recently took up the petitions of John A. Enos and others, for authority to build a system of elevated railroads in the town of Winthrop and from Nahant to Lynn. After some discussion between the committee and the counsel for the various parties interested, the committee decided to go into the merits of the Enos system of elevated road, as well as its incidental practicability in the special districts where a trial is desired. Mr. F. E. Farnum, of Peabody, counsel for Mr. Enos and for certain citizens of Winthrop, then explained the system of road and replied to some of the objections that had been raised to electrical elevated roads. Mr. E. H. Doolittle followed as a representative of the proposed company, and called Mr. Upton, of the Jarvis Engineering Co., who explained the system of electric roads in the city of Baltimore. Mr. E. S. Reed, chairman of the board of selectmen of Winthrop, explained the position of the town on the matter, as did Mr. Warren Belcher, who gave some of the details, votes and resolutions in town meetings.

BOSTON, March 15, 1886.

CHICAGO.

Local Interest in the Telephone Question.—The Era of Railway Strikes.—Electrical Devices for the Instruction of Deaf Mutes.—Adaptation of the Morse Alphabet for Communicating by Touch.—Increasing Telegraph Facilities.—The Underground Service a Severe Test for Insulation.—The New Arc Lamp Hangers.

THE daily press everywhere is full of the latter day Tichborne case, and the journals here are especially crowded in that line, by reason of this being the residence of Prof. Gray, so far as business is concerned; and Mr. D. K. Tripp, who is the professor's attorney and counsel as well as an officer in the sectional underground company of which Gray is the president, is constantly called upon by reporters, wonder-mongers, and other interviewers to make a few statements relative to the case in hand. So Chicago is treated to a foreign or local item on the telephone situation every morning to go with the steak and coffee, the "all about the murder" and the other pleasant little items of so-called news of the day.

Just now by way of pleasant variety we are having an over-product of railroad strikes which betoken anything but a healthy state of affairs in the future, unless some reasonable conclusion is shortly reached. It is a good time for those who are being entangled in the meshes of unions to look about them, and be sure where they are to land before they leap. The telegraphers, telephoners, and other electrical employés should remember the many dismal failures of such organizations, which are on record, and govern themselves accordingly.

In a recent number of "American Annals of the Deaf and Dumb" is an article by the superintendent of a Western Institution for the education of these unfortunates, on the subject of communication between deaf mutes by electrical appliances. While the arrangement indicated is ingenious and quite original, to an old telegrapher it looks clumsy and awkward enough. The plan as described, consists of a wire for each of the twenty-six letters of the alphabet, with a branch wire from each of these to the desk of each pupil in the class to be taught. At each desk, a matrix or shell is placed which fits the palm side of the left hand of the pupil. This is perforated so as to permit of blunt needle shaped attachments being forced up against the hand at several points on the fingers and palms, each letter puncher being restricted to its particular locality. Twenty-six buttons at the teacher's desk represent the twenty-six letters, the twenty-six needles and the twenty-six places where the twenty-six wires are thrust through twenty-six holes in the matrix, by means of some actuating process not explained—presumably twenty-six electro-magnets! To keep an apparatus like that in order in a good sized deaf-mute institution, and prevent monkeying with the buzz saw, would require at least twenty-six line men and twenty-six special police, unless it worked better than such complications in such places usually do.

Now the way a practical operator would have arranged that thing on this side the Atlantic, would have been to put a lot of electro-magnets, one at each desk, where the armature would strike the foot or the hand, or the back, or any other desired part of the body, and give every operator a key so he could talk back, for there is no fun in school, unless you can "sass the teacher." One wire, one magnet and key, at each desk, the Morse alphabet with phonetic abbreviations for ordinary conversation, a call for each individual—that would be an American operator's system. If we all lived in Europe we would probably follow the other chute, and put step-by-step instruments in the place of sounders, or perhaps only one—at the teacher's desk, and teach by sight.

The idea of teaching by touch is by no means new, but was introduced at least ten years ago in the Delavan, Wis., asylum by Prof. C. H. Haskins, of Milwaukee, who at the time was a member of the state board of charities and reforms. In the course of some remarks which were translated into sign language by the teachers, the professor suggested the use of the Morse alphabet communicated by touch, and he left a copy of the alphabet with the teachers. The quick perceptive faculties of the little ones were not long in compassing the situation and the plan worked splendidly. By this means they could converse in the dark, and without being discovered, provided they could touch feet, hands, or other portions of the body. An element of discord developed from the very facility and ease with which it could be used. Jealousy is a prominent characteristic of the deaf mute, who can only see what may be going on. Deprived of the use of this one faculty he imagines, and is uncomfortable because suspicious. Almost endless complaints were made by the scholars of their mates talking about them, because when two were engaged in secret conversation, if they happened to glance toward a third, an offense and a complaint were nearly sure to result.

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The Morse alphabet was driven out of the asylum, because of the trouble it caused.

Telegraph facilities are constantly on the increase here. The new envelope bearing the legend of the United Lines has apparently come to stay, and rumor gives us a promise of eight or ten new wires by this route to New York, six to Minneapolis and St. Paul, with four from there to Duluth. These north-western lines are to be run by the North American company, but will connect here with the United Lines company's wires.

This underground business is a severe test in the matter of wire insulation. This is especially the case with electric light wires—the high potential of an electric light current, gradually but constantly increases any little leak there may be in the insulation of such conductors. It is undoubtedly true that cases may exist where the action of a current has put a temporary stop to a leak, by electrolysis, but the other condition is far more frequently met. The result of this species of test for underground wires, has been disastrous to a large number of brands, and the number of wires which bear the Chicago endorsement to-day is extremely limited. There are good wires for such purposes, and these cost more money in the outset than some others ; but they pay in the end. Almost any quantity of poor wire has been tried, condemned and thrown out here as unfit for use. In nearly every department of electric lighting the prize ring motto is applicable. With fair play the best must win.

The new electric light hanger for outside lamps is proving a marked success, and is being very generally adopted. Arrangements are being made for supplying the essential parts only, which will permit of shipment, at small cost of transportation, and allow the purchaser to furnish the rods to suit his own fancy as to length, etc., and place his own hangers.

CHICAGO, March 14, 1886.

WASHINGTON.

The District Court Grants Electrical Companies the Freedom of the City.—Telegraphing by Contract.—Investigating the Telegraph Deals of the Pacific Railroads.—Successful Installation of an Edison Panorama Plant.

THE District court in general term on the 7th inst. summarily swept away the decision of Judge Hagner, granting an order restraining the Western Union Telegraph Co., from erecting a certain line of poles on 7th street. The court ignored the law as well as the science of the learned judge, and goes still further, holding that "any company now organized or which may hereafter be organized," has the *right* to erect their lines without even asking the consent of the commissioners, and it follows that they are equally independent of the citizens, so long as they do not encroach upon their private property. With these broad privileges assured them, the telegraph companies will not be hasty in underground experiments within the District of Columbia, and the telephone companies can readily erect their poles, under the patronage of some of the telegraph companies if the claim is made that they are not embraced in the act This being a United States law, the decision does not affect the status of the wires where state laws prevail.

The House post-office committee having decided not to consider any proposition to build or purchase telegraph lines, gave a few days to the consideration of schemes for contracting for telegraphic despatches, as the mails are carried from point to point. The outline of the leading scheme is for the government to sell stamps to cover transmission and delivery. A stamped despatch is dropped into any post-office, whence it is forwarded to the nearest telegraph office, of the contracting line or lines, by them transmitted to the post-office most accessible to the point of delivery and again turned over to the postal service for delivery. Three or four cents is to be added to the contract price, to cover cost of collection and delivery, which the government undertakes to do. But for the element of time, this scheme might prove practicable. The committee is not enthusiastic on the subject and nothing is likely to come from it.

The full committee is just now devoting more energy to the consideration of Mr. Anderson's proposition to inquire whether the land grant railroad and telegraph companies have not violated their charter by giving to the Western Union Telegraph Co. a monopoly of telegraphic transmission over the territory practically controlled by them so far as telegraphic service is concerned. Some legislation, hostile to the railroads (which every congressman is anxious to kick), may grow out of this inquiry.

The Edison company has recently completed the plant for the panorama of the battle of Manassas, or second Bull Run, which opened here on the 2d of March. They have 300 lamps in a circle and around the dome of the building which covers the painting. The engine, dynamo and wiring was put up within a fortnight. When the engine was started and the current turned on every lamp was found up to the standard, and the lighting went off without a hitch of any kind. The time in which the work was done and the success which attended it, indicates a degree of perfection in their system seldom obtained in the introduction of electric lighting.

WASHINGTON, March 17, 1886.

SAN FRANCISCO.

Electrical Affairs Quiet.—Effects of the Recent Gale.—An Astonished Butcher.—Progress of the Motor Company.—Another Extraordinary Primary Battery.—Experimenting With Long-Distance Telephone.—The Business System of a Telegraph "College"

ELECTRICAL matters in 'Frisco appear about the same as usual. Nothing of extraordinary moment has occurred here of late. The air is full of rumors, nevertheless, but the work seems to be nearly all "underground." However, "Rome wasn't built in a day," and ere long things promise to be quite lively in this section of the country—especially fleas and cockroaches.

The telegraph and telephone service was literally "paralyzed" during the late storm which caused houses, fences and out-buildings to meander about in the atmosphere, and if the average man's shanty wasn't blown over during the night, he awoke in the morning to find his sacred domicile comfortably settled on some other fellow's ranch, ten or twenty miles away—that is, more or less. If there wasn't a break somewhere there was a leak, and at least one man hereabouts was not only deeply impressed by the latter fact, but also in the mud. It occurred in this wise: an electric light wire fixed to the roof of a meat-market was leaking badly during one of the nights in question. The current escaped by way of a tin gutter running down the side of the house, which was in metallic contact with an iron meat-supporting frame. An employé of the shop had occasion to remove a quarter of beef from one of the hooks, and on lifting it off was seen to stagger into the street and drop like a log. Although the shock had no fatal result, he is extremely likely to remember it.

The Pacific Electric Motor Co.. was organized here some time ago, but has not yet got under way, though active preparations are being made. The object of the company is to furnish electric power throughout the city in the same fashion that the electric light is dispensed at present. Its business, at least for a time. will be limited to the propulsion of light machinery. The motor to be used is that known as the Stockwell. The corporation has leased the poles of the California Electric Light Co., for the term of five years, and will begin stringing its wires shortly. The electric light company, which has already a dozen 60-light Brush machines in operation, is enlarging its works, and will supply the current. The motors will be furnished at a monthly rental of from $1.50 to $2.00. More than one pack of motor fiends has "gone up the spout" within the past three years in this city. Let the Pacific company settle the fizzle business.

San Francisco has unearthed another prodigy. According to his statements he has invented a new battery, a single cell of which, he claims, will light an ordinary-sized dwelling ; and with one similar element he has actually fused the coils of a local sounder! Heaven forbid! He does not propose to divulge the secret until he has thoroughly tested it; and at the same time, let me whisper in confidence, he is engaged in constructing one of those machines which requires "just one more wheel" before it will operate. He *knows* it will work—poor fellow.

The ignorance of the average citizen in regard to electrical matters is sometimes highly amusing. A gentleman recently asked "how many batteries" were required to run the lights in the city ; on being told that instead of "batteries" an electric generator driven by a steam engine was used to produce the current, he replied with a knowing smile, "Oh, I see! you have to have a steam engine to pump the 'lectricity through the wires!"

It is reported that Jno. I. Sabin, general district telegraph and telephone manager and superintendent, has been experimenting with a new transmitting telephone, between here and Sacramento. Conversation in any part of the room is transmitted and understood as readily as that of the average telephone on a short circuit. "John I.," appears extremely reticent as to its character, and will allow no one to handle it. The only prominent feature of the apparatus is a huge magnet two feet in length, said to be so powerful as to cause the iron pillars in the neighborhood to fairly crack under the strain. Indeed one employé, who was unconsciously passing near the instrument with a screw-driver was amazed at finding the tool violently wrenched from his grasp and propelled with astonishing velocity in the direction of the magnet, to which it stuck like grim death; may be it is hanging there yet.

The "Union Telegraph Co.," has again received a well-deserved "dig," and it is certainly high time that its nefarious practices were stopped. Its business consists in filching poor young men and girls, out of the few dollars they possess. Their "bait," has been running in the male and female help columns of the daily press for years, after this fashion :

Wanted—For January 1st, two more young ladies to learn telegraphing on our lines for offices, paying $50, to $100 and $150, per month. Apply to superintendent of Union Telegraph Co., 640 Clay street.

The workings of this institution were twice exposed—the first time in 1882. At that time the deluded young men and women left in a body, and for a while the concern suspended operations. It is no transmitting telegraph company, possesses no lines outside of its rooms, or rather *room*—which is nothing more than a good-sized closet on the top floor of the building, it has no influence to secure situations anywhere, and last but not least, it is incapable of teaching the art. The method pursued by the

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alleged company is as follows: A person who answers the advertisement is informed that tuition, until the pupil learns the business, must be paid for. From $20 to $60 is charged, and once the money is paid, the dupe is permitted to discover at his leisure the fraud perpetrated upon him; and in addition to the sum charged for tuition the pupil is sold a text-book for $2. On receiving the money the "company" prepares a gaudy receipt with an enormous red seal in the corner, signed by "T. Gates Clarke, secretary, per J. T. Welham, superintendent." On the back is a set of rules and regulations, one of which prescribes "no positions promised." The applicants seldom or never read them on entering the "college," deeming them of no consequence, nor are they requested to do so. The "rule" is cunningly inserted in a mass of rubbish about talking during school hours, etc., and not one in fifty ever sees it till a protest is made to the manager. It is then that the pupil learns that he or she has unwittingly signed away the right of redress. I will cite one of many instances: A certain young lady from the country was lured to this den on seeing the advertisement, which promised easy work and big pay. Her parents are dead, and in order to raise sufficient money to pay her "course" and keep her while here, she sold her piano—which, by the way, is about the last of earthly possessions the average lady is willing to part with. When the delusion was discovered it well-nigh broke the poor girl's heart. The commercial telegraph companies flatly refuse to employ any graduate of the school, and superintendent Frank Jaynes, of the Western Union, states that they have become such unbearable nuisances that he was on several occasions compelled to invoke the aid of the police. It is a crying shame! And why certain influential publications aid in this rotten practice by persistently printing these sharpers' lying, thieving paragraphs is a mystery. Let it be stopped! The sooner it is done the better it will be for all concerned.

SAN FRANCISCO, Cal., March 10, 1886.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICIAN AND ELECTRICAL ENGINEER, 115 *Nassau Street, New York city.*

THE RECENT TESTS OF INCANDESCENT LAMPS.

[50.]—My attention has been called to a letter of Messrs. Woodhouse and Rawson, of London, published in your issue of February, 1886, and elsewhere, in which they repeat a calumnious statement of a New York paper of June 13, 1885, but omit to add the contradiction by the secretary of the Franklin Institute, published in the following number of that paper, of June 20th, as follows:

[From the *Electrical Review*, June 20, 1885.]

Ed. *Electrical Review*:

My Dear Sir:—Do me the favor to correct in your next, what I take to be an unintentional mis-statement of my remarks regarding the "Electrical Tests," which appeared in last week's issue, and for which I must disclaim responsibility.

I stated to your representative, as I have invariably stated to numerous other inquirers, that I could give little or no information regarding them, and that the proper person to apply to for information was Mr. Tatham. Beyond this, I do not recognize the statements credited to me as my own.

Yours truly, WILLIAM H. WAHL,
PHILADELPHIA, June 16, 1885. *Sec'y Franklin Institute.*

No other notice, as far as I know, was taken of the article, and the story died of its own absurdity.

The reason given by Messrs. W. and R. for reviving this defunct slander is, that rival makers of incandescent lamps are prodding them with the report of the judges appointed by the Franklin Institute to test the efficiency and duration of incandescent lamps.

It is true that the Swan, the Maxim and other companies did not enter their lamps for the tests for various reasons, but no one had any right or reason to apprehend that they would not be fair tests, and no one now has any reason to say they were not conducted fairly. In the conduct of the tests, the cardinal principle was to do right, and also to avoid all appearance of wrong-doing. To this end, a code was adopted and judges selected, with the full concurrence of the contestants, and nothing was concealed from the parties in interest. The contestants were invited to inspect and did inspect every step in the progress of the tests. Their experts compared the photometric measuring powers of the judges with their own. I believe it would be impossible to find four men better equipped and experienced for their duties morally, mentally and physically, than the four judges of these tests. I was a daily witness of their work, and weekly progress reports of the tests were made to the Franklin Institute.

So much for the general indictment; and now for the particular complaint.

It is, *first*, that their lamps were tested without their knowledge or consent. *Second*, that their lamps were run at five volts above what they were labeled.

Two lots of their lamps were tested. The first lot, selected at random from a barrel of lamps belonging to the Van Depoele company, were labeled 20 candles, 55 volts. They were tested and run at 55 volts. No. 9, with resistance cold of 106 ohms, lived longest, 715½ hours. No. 2, resistance cold, 102 ohms, exhibited phenomenal brilliancy. The complaint that this lot of lamps was entered without their knowledge or consent, may be well founded.

The second lot of lamps was received through the Edison company. I now learn that the origin of this transaction was as follows:

At a meeting of the London Society of Arts, held December 3, 1884, Mr. Wm. H. Preece, F. R. S., read a paper upon "Electric Illumination," in which appeared the following language (see *Journal of the Society of Arts*, December 5, 1884, page 73):

The efficiency of the glow lamps has also been very considerably affected by the improvement made, for instance, by Messrs. Woodhouse and Rawson and by Mr. Bernstein.

The efficiency of the Edison lamps means the consumption of energy at the rate of five watts per candle, but lamps are now being made which give an efficiency of two and a half watts per candle with an equal life, which is equivalent to an immediate reduction of 50 per cent. in the amount of energy required to maintain the system alight, and therefore in the cost of production.

Whereupon the Edison company challenged Mr. Preece to produce such lamps and have them tested by the Franklin Institute, whose committee was preparing for the tests which afterwards were made.

Mr. Preece procured the lamps and forwarded them to the Edison company, whose letter dated April 13, 1885, to Professor Marks (who acted as an executive committee), says: "Mr. Preece, the electrician of the English post-office, has sent to Mr. Edison a number of Woodhouse and Rawson lamps. They are now in the New York Custom House. We have given directions to have them forwarded to you at the electrical exhibition in the original packing as soon as they are appraised."

At that time our test boxes were all occupied and our current employed.

Inside of the box when received, was found a large label addressed "for Mr. Wm. H. Preece, 20 candles, 50 volts." The usual label of Woodhouse and Rawson was on every lamp, altered, however, so as to read as above, the figure 0 in the number 50 being written over an erasure. The resistances cold of all the lamps tested was nearly uniform, five at 100 ohms; two, each 99 and 101 ohms, and one 102 ohms. (See Report, Table VI, page 38.)

These circumstances persuaded us that the lamps were not selected by chance.

They were tested and measured for horizontal and spherical efficiency upon the 7th May, both at 50 volts and at 55 volts with the results shown in the following table, which I have made up from the original records.

WOODHOUSE AND RAWSON LAMPS. (Second lot.)

Measurements of Horizontal and Spherical Efficiency, at 50 Volts and at 55 Volts. Compared. Made May 7, 1885.

Lamp No.	Volts.	Ampères.	Watts.	Candles Averaged.		Watts per Spher. Candle.	Watts per Horiz'l Candle.
				Horizontal.	Spherical.		
30	50. 55.	1.071 1.167	53.75 64.18	14.19 22.73	11.48 18.52	4.68 3.46	3.79 2.82
31	50. 55.05	1.084 1.182	54.20 65.07	12.38 20.93	9.93 17.28	5.46 3.76	4.38 3.11
32	50.03 55.	1.084 1.195	54.23 65.72	12.43 21.28	10.47 17.36	5.18 3.78	4.36 3.09
33	50. 55.05	1.089 1.188	54.45 65.40	14.07 22.67	11.75 19.01	4.63 3.44	3.87 2.88
34	50.03 55.	1.050 1.147	52.53 63.08	12.52 20.78	10.34 16.91	5.08 3.73	4.20 3.04
35	49.95 54.95	1.046 1.139	52.25 62.58	14.48 23.53	11.73 19.56	4.45 3.20	3.61 2.66
36	49.95 55. •	1.088 1.191	51.35 65.50	15.68 25.98	13.05 21.41	4.16 3.06	3.47 2.52
37	50. 55.	1.086 1.185	54.33 65.17	13.88 22.93	11.51 18.74	4.72 3.47	3.91 2.84
38	50.05 55.	1.097 1.197	54.90 65.77	12.24 20.70	10.05 17.84	5.46 3.69	4.49 3.18
39	50. 55.	1.089 1.186	54.45 65.23	11.88 19.74	9.73 16.33	5.59 3.99	4.58 3.41
Average Average	50. 55.	1.0784 1.1777	53.944 64.770	13.375 22.127	11.004 18.296	4.941 3.557	4.066 2.955

Upon discussing these preliminary results, the judges found it impossible to follow the label. Twenty candles illumination could not be had with 50 volts, and they decided to raise the electro-

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motive force for the following reasons : There are three points of excellence in incandescent lamps—brilliancy, duration and economy. The boast for these lamps is that they are brilliant and cheap. It would not benefit their reputation to test them with 50 volts, at which the preliminary tests show that they are both dim and dear, for the sake of increasing their duration, of which the remaining time of the tests, about 300 hours, would furnish no proof.

In this decision the judges were governed by a desire to do for the lamps what they thought the makers would do if they had been present and aware of all the facts. The judges made no concealments of what they did, nor of their reasons for it. They published the results of the tests with 50 volts, but not prominently.

It was out of kind consideration for the makers of the lamps that the judges raised the electromotive force, and it was out of a like consideration that they did not publish a table like the above.

These considerations, Messrs. Woodhouse and Rawson have trampled under their feet, and have turned again to rend the committee.

I am unable to see the least shadow of unfairness in the proceedings of the judges, and I ask all those journals which have published the letter of Messrs. Woodhouse and Rawson to publish this reply. I am, very respectfully, W. P. TATHAM,

President of the Franklin Institute.

ERRORS IN THE BROWN AND SHARPE WIRE GAUGE.

[51.]—Permit me to call your attention to some errors found in most of the tables giving the values of the B. and S., or American standard wire gauge. In trying to find a relation or equation between the diameter and number of a wire according to this gauge, I found that the value of No. 0, as usually given, was apparently incorrect, as it did not follow the general law existing between the other values. Upon inquiry at Messrs. Brown and Sharpe, I found that this value and that for No. 19, were not given correctly in one of the catalogues, from which they were apparently copied for the tables now in general use. The value for No. 0 should read .32486″ and that for No. 19, .035891″. This, of course, will change the values of the resistances, weights, cross sections, etc. of these numbers in the tables in use.

The manufacturers also kindly informed me what the exact law was, from which the values are calculated. From this law I found a number of other errors, but as they are almost exclusively in the 5th place of figures, they are insignificant, as wire is not generally if ever, drawn to such accuracy.

I should also like to add here, a few words in defense of the much abused "wire gauge system." In most text books the authors advocate abolishing the wire gauges and using in place of them simple decimal fractions as diameters of the wire. A little thought, however, will show that such a system will not give nearly as rational a system of sizes as that of the American wire gauge, because in the former the decrease in sizes must necessarily be a quantity which is not constant but which varies in steps, as it might be called. In the American gauge the decrease in the diameters, and therefore also in the cross section, is a constant ratio, each diameter being approximately .9 (accurately .890525) of the preceding, or each cross section about .8 of the preceding. Such a scale must necessarily be much better adapted to the use of the electrician than one decreasing by decimals. What the practical engineer wants, is not so much to save a very little time and trouble in a somewhat shorter multiplication or division, as to have a regular system of sizes without abrupt steps.

It may not be out of place here to call attention to some errors in the table of resistances published in this journal among the advertisements. Besides those given above there are the following. They should read :

No. 0,	cross section,	82887 sq. mils.
14,		3225.4
19,		1011.69

The logarithms for Nos. 12 and 26, should begin with the numbers 3 and 2 respectively, and not 4 and 1.

There are other errors in the fourth and fifth places of figures in both diameters and cross sections, also in the last five places of decimals in the logarithms. They are too numerous to give here. For most calculations they are not important. The corrections above given will, of course, change the rest of the numbers given in connection with those sizes. Yours truly,

CARL HERING.

PHILADELPHIA, Feb. 8th, 1886.

THE HEATING AND COOLING OF INSULATED CONDUCTORS.

[52.]—In an article in the February ELECTRICIAN AND ELECTRICAL ENGINEER, Carl Hering, in speaking of "some calculations or statements made, that insulated wire will cool more rapidly than naked," seems to imply a doubt whether such is the fact. A mathematical investigation does show that, under certain conditions, insulated wires will cool more rapidly than naked, and to determine whether these conditions obtain for the insulated wires used in practice, a series of experiments were made last spring and summer at the physical laboratory of the Cornell University, upon nearly all the styles of insulated wire in common use. The experiments were conducted by Mr. J. G. White, who made the matter the subject of a thesis for the degree of doctor, and, as the whole investigation will shortly be published, only the general methods of experiment and the results will be given here. Wires in lengths of about 100 feet, half covered and half naked, of various sizes and styles of insulation, were obtained from the manufacturers. One of these wires being strung up in such a way that the covered and naked portions were equally exposed, a current, increasing in strength from one whose heating effect was inappreciable, to the largest the wire would bear, was sent through the entire length of it, and the resistances of the two portions measured, while the current was passing. To provide for the measurement of the resistances the wire was made to form one branch of a Wheatstone's balance, the other branches of which were so arranged as not to be heated by the currents that flowed through them. In *every case* the resistance of the naked wire increased much more rapidly than that of the covered, and, in general, the thicker the insulation, the less the increase in resistance. In the case of a "Clark's" insulation, for instance, where the wire was 65 mils, and the covering 285 mils in diameter, the increase in resistance due to heating by the current, was, I think, about three times as much for the naked as for the covered portion. I was myself surprised to find that the effect of the covering to keep the wire cool, was the general, and not the exceptional effect. In what respect a covered wire differs from a covered steam pipe, will appear when the complete account of this investigation is published. WM. A. ANTHONY.

PHYSICAL LABORATORY OF THE CORNELL UNIVERSITY, Feb. 16th, 1886.

UNDERGROUND TELEPHONE WIRES.

[53.] Referring to letter number 44 in January, and 47 in February, we can show Mr. Lockwood or any disinterested person a better working wire, telephonically underground five miles using the earth for a return circuit, in this city, than can be shown of the regular overhead service working one half mile, or ten times as well working equal distances. H. C. FREMPT,

Sup't Brooks Underground Conduit Co.

PHILADELPHIA, Feb. 14, 1886.

[As the discussion of this question has been based upon a report in these columns, which was the result of my personal experience, it is proper to state that I made no investigation as a telephonic expert, nor did I attempt to verify the assertions of Mr. Brooks or his representatives as to the wire being a metallic or a grounded circuit.

In the first place I was told that it was a metallic circuit. The wire under those conditions was practically free from inductive disturbances. At my request it was changed to a grounded circuit, after which the effects of induction were manifest, but not annoying. The articulation in both instances was perfect, and communication in every respect superior to that afforded by the ordinary city exchange service with which I am familiar.

I have not undertaken to prove that the excellence of this particular telephone line is due to the fact that it is underground, but simply to state that so far as the predicted evils attending subterranean telephone wires are concerned, I must in this instance render the Scotch verdict of "not proven." A subsequent personal test in November merely confirmed my original experience.

I do not wish to be understood as conveying the impression that a special case of this character is to be taken as a precedent for burying an extensive system of local telephone wires, but simply that this particular line, would have been far more satisfactory to a subscriber, than are those with which he is ordinarily connected, and that if retardation existed it was to such an inappreciable extent that its effect upon that length of wire was not readily detected.—R. W. POPE, *Associate Editor*].

LITERATURE.

REVIEWS.

Berly's Universal Electrical Directory for 1886. London : Wm. Dawson and Sons, 388 p.

This is the fifth annual publication of a work which has not only established a field for itself, but has led to similar ventures by others. The present volume is smaller than its predecessors, by reason of the contraction of the American section, which, however, still contain the names of establish-

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ments and individuals, especially devoted to electrical work. The price of the book has been correspondingly reduced, and it should therefore find its way into the hands of all who are interested in electrical merchandising.

The Electrician's Directory with Hand-book for 1886. London: George Tucker, office *The Electrician*, 160 p

This work in addition to its value as a directory, contains several tables for the use of electrical engineers, a list of the municipal authorities in English towns having over 10,000 inhabitants, also brief biographical sketches of well-known electrical engineers, electricians and inventors on both sides of the Atlantic. The table of electro-equivalents, which is here given a prominent place, was first published in the columns of the ELECTRICIAN AND ELECTRICAL ENGINEER, and it would have been proper to have awarded due credit for its preparation to our esteemed contributor George B. Prescott, Jr.

RECENT PUBLICATIONS.

Gordon, J. E. H. School Electricity. London. *Sampson Low, Marston, Searle and Rivington.*

Tarn, H. C. Magnetism and Electricity for the use of students in schools and science classes. London and Edinburgh. *W. and R. Chambers.*

Watt, Alexander. Electro-Deposition. A Practical Treatise on the Electrolysis of gold, silver, copper, nickel and other metals, with descriptions of voltaic batteries, magneto and dynamo-electric machines, thermopiles, and of the materials and processes used in every department of the art, and several chapters on electro-metallurgy. With numerous illustrations. New York. *D. Van Nostrand.* Crown 8vo., 568 pages. Price, $5.

CATALOGUES RECEIVED.

Prof. A. K. Eaton, 65 Henry street, Brooklyn, issues a general list of the am-meters, volt-meters, and volt-am-meters, and other varieties of measuring apparatus manufactured under his patents, and with his personal supervision. An illustrated description of a portion of these instruments, appeared in these columns October, 1884.

The Jarvis Engineering Co., of Boston, in a fully illustrated catalogue recently issued, give many interesting facts in connection with steam generation and the installation of electric lighting plants. The gentlemen connected with this company have had great experience in this line, considering the short time which has elapsed since electric lighting has progressed from the experimental to the practical stage.

The Household Electric Light Co., of Boston, as its title indicates, is devoting special attention to the domestic electric lighting industry. The Mather-Perkins system has been adopted for this work, and the pamphlet issued by the company, which will be forwarded upon application, contains much interesting information upon the subject, as well as an illustrated description of the electrical apparatus used. The incandescent dynamos range in size from the one light machine weighing but 35 pounds up to that of 500 lamp capacity, and of 5,000 pounds weight. Four sizes of motors are also supplied. There are so many locations in the country where small plants will eventually be introduced, that a little thought given to this subject while it is comparatively new, will not be misdirected.

ELECTRICAL NEWS AND NOTES.

THE STORY OF PAN-ELECTRIC.

The history of the organization of the Pan-Electric Telephone Company, which has been brought out by the congressional investigating committee is a matter of considerable interest as showing the methods practised in the exploiting of such enterprises. The story as given by Dr. J. W. Rogers is apparently true in every respect and is supported by corroborative evidence. Dr. Rogers is a practising lawyer and has been identified with the company since its foundation. Its formation was mentioned to the doctor and his son J. Harris Rogers in 1881 or 1882. Mr. Hine originally intended to purchase the old Chase mansion as a laboratory. On account of a defect in the title however, a house was purchased for $10,000 on 4½ street instead, but it was discovered that the hiring of skilled men and the purchase of materials involved so great an expense that the organization of a stock company was suggested by Dr. Rogers. They naturally turned their attention to the subject of great names—of men of influence. In that view the doctor wrote to or called upon Gen. Atkins, then chairman of the appropriations committee. Atkins seemed pleased with the idea. A few days later the doctor saw Senator Harris, who had already talked with Gen. Atkins on the subject. They came to his house with Casey Young. He offered to each one something like $100,000 of the stock on a basis of $5,000,000. They had hesitated—at least Senator Harris, more than any other, had hesitated—about going into it, and nothing was done at that meeting.

Thereupon it had occurred to him that Senator Harris might be apprehensive that there might be some impropriety in his advancing the enterprise, and the doctor had written to Senator Harris to inquire whether he entertained any feeling of that kind. He replied in a letter very frankly that he did.

Senator Harris in his letter, had replied that he had duly considered the matter and saw no impropriety in persons situated like himself and Gen. Atkins taking part in a scientific enterprise such as had been proposed. But still he did not go in. There was nothing in his letter to indicate any such intention. Subsequently a meeting of the gentlemen was held, probably at the doctor's invitation. There were present Senator Harris, Gen. Atkins and Casey Young. It was proposed that each take $500,000 in stock. They agreed and entered the enterprise. The doctor had suggested to the gentlemen that several others had previously consented to act as directors, but he left it chiefly with them to select their associates. None of the other persons had been members of congress. One of the persons was Father Rochefort, his son's patron; another Gen. Marcus Wright, another was Richard Wintersmith. There was also C. G. Schneider, a merchant of Washington; Gen. Basil Duke, of Kentucky; Nicholas Shea, of Washington. Those gentlemen had allowed their names to be used, and for them he had reserved the $170,000 stock to be put to their credit.

It was understood that these gentlemen were parties to the concern, and they talked it over just as partners would.

Senator Harris said that they would come in and they seemed by their coming to acquiesce. When the doctor proposed to give $500,000 in stock to each gentleman Senator Harris said it seemed to be a little too generous, but, as they expected to make enough money for everybody, they would accept the stock.

The doctor had written to Senator Windom, Benjamin Lefevre and Architect Clark that he had a small amount of stock to their credit, but they had all declined. The gentlemen associated with himself in the company were to pay nothing for their interest. He wished to secure the co-operation of men of integrity and of national reputations. Without the names of such men the stock could not be sold. Gen. Johnston did not hold a public office at the time he associated himself with the enterprise.

Nothing was said by any of the gentlemen with reference to the company deriving any advantage from an official position held by any one of them. The object was to bank on their names and reputations and his son's genius.

The doctor said that after signing the agreement in New York the company appointed his son electrician, and telephonic experiments were made over a wire between New York and Washington that resulted satisfactorily. The original Pan-Electric company was never chartered, although the contract provided for a charter. After a year or two it was agreed to take out a charter in Tennessee for a telephone company; Looney and Brown had joined the original membership, and the doctor had acquiesced in the agreement, because there was so much difficulty in getting the "big charter," and he believed it best to go on in a smaller way. Two meetings were held in the room of the senate judiciary committee for the organization of the telephone company. There were present Looney, young Rogers, Senators Harris and Garland and Gen. Johnston. Gen. Atkins was not there. At the first meeting a general agreement was reached. Senator Garland prepared the papers and submitted them at the second meeting. A charter for a telephone company was obtained in Tennessee, and one for a telegraph company was obtained in New York. Senator Garland had prepared both charters for New Jersey, but the doctor found that the state charge was too high. The foundation for the telephone company was several inventions of J. H. Rogers in the art of telephony, and for the telegraph company a patent for an embossed metallic tape. There never was any Pan-Electric stock issued, but the secretary sometimes signed pen statements to the effect that the party had so much stock in the company. Great difficulty was experienced on account of the non-issue of stock, and it was a constant source of irritation among the members of the company. The certificates were about as follows:

"J. W. Rogers is entitled to $500,000 in the Pan-Electric Telephone Company.

"(Signed) CASEY YOUNG, Secretary."

The doctor said his son and Looney were chiefly desirous of having the stock issued, while Senator Harris opposed it "I believe he was the head of the whole business," said the doctor, "that is the opposition. He had great influence over the rest of them."

The doctor had complained about the delay in the issue of stock. Senator Harris had thereupon visited his house and said that the demand had been considered by the board, and as for himself (Senator Harris) he had made up his mind to withdraw from the association rather than allow stock to issue. The doctor insisted upon his demand. The senator seemed to believe the witness would be stricken with a chill at the idea of the withdrawal of the great men. The doctor had replied: "We shall be very melancholy, senator, if you withdraw."

The doctor supposed the gentlemen were unwilling to have their names go on the stock because they regarded them as sacred. "It was also suggested in conversation," said he, "that possibly this whole thing will fail, and in that case all concerned would be looked upon as scoundrels." So they had refused to go forward, and trouble and friction had ensued, and he had finally decided to bring a suit in equity. Looney persuaded him not to do so, however, saying that it would result in further trouble, and so it had just jolted along down to the present time. The doctor's object in trying to get the stock issued was to raise money on it to pay expenses. So far as he knew, the original associates held all of their stock at the present time.

He then gave a long account of the establishment of the various local or state companies operating under the Pan-Electric Telephone charter.

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Col. Looney had made most of the sales of state rights, he said, beginning with Tennessee, which was sold for $10,000. The money was divided among the associates the doctor presumed: at least he got his pro rata. Then Looney had gone to Texas, where he had used the wire fences for telephonic transmission, "and the women and children began to cry for the telephone." Looney had also sold the Texas right for $10,000 cash (which was divided) and one-quarter of the local stock. The last the doctor heard from Texas was that women and children were crying for the stock. (Laughter.)

The doctor also told of a small bill that had been incurred, which Casey Young would not pay because he was "getting tired of it," and which Gen. Johnston had refused to pay because it was made out in Rogers's name. Thereupon the doctor and his son had become so provoked that they had gone over to New York to establish an independent telephone company. There they had met Mr. Beckwith, who professed his ability. "I never agreed with you to start any company," interjected Mr. Beckwith, who sat in the committee room.

The doctor said Mr. Beckwith had told him he could get more money for them than those old statesmen could get. He refused to put in money, but said he would use his influence. Upon consultation, however, they found that Harry (his son) had bound himself to the association (Pan-Electric) so far as his inventions were concerned.

Referring to the subject of local companies, he said that Looney had sold the Alabama rights for $7,500, which the associates had received, together with the money for the Tennessee rights. New York had been sold originally for $2,000,000 in stock to "enterprising sons of Alabama." Gen. Harris thought they could get more out of it in that way. After some negotiations the doctor and his son, with Messrs. Klotz, Money, Denver and Manning, secured the Pennsylvania rights; that was early in 1884. The Pennsylvania company had established an exchange at Mauch Chunk, and at other places in the vicinity. The District of Columbia and Maryland were also sold. Chicago was sold for $10,000, of which, said the doctor, "I got my slice."

The doctor gave Looney $600,000 of his own stock. The company had previously offered him $50,000, which he spurned. Gen. Boyle bought some stock at $10 a share—about $1,000 worth in all.

Mr. Looney paid nothing; it was Looney's genius he was banking on; just as he had on the other gentlemen's names.

The doctor did not know that any of the local companies had made any money; he had never received anything beyond the dividends for the state rights. He believed that they had in St. Louis.

Regarding the establishment of the American Postal Co., of which he was the originator and principal stockholder, some of the stockholders, he said, were his personal friends and offered to drop out if he could get prominent men in Washington to take their places. He had offered the Pan-Electric people $1,000 in money and $1,000,000 in postal stock for one of his son's patents which had been assigned to the Pan-Electric. That offer had been refused, and he thereupon proposed that the Pan-Electric take hold of the Postal Telegraph. The Pan-Electric had a meeting at the Metropolitan Hotel, at which he was not present, and Senator Harris informed him that they would make a counter proposition, which they never did. Then the doctor cast about him in Congress for "another great man."

Messrs. Money and Manning had been offered a few thousand shares of the stock, but he would as soon put his head in a lion's den as try to bribe either of them They were old friends of his. Then Dr. Hassler, of New York, had introduced him to W. E. Robinson, "the lion man,"—who promised to entertain his proposition. He gave him $10,000 stock. He told every man he ever sold stock to, that the only place he would guarantee he could get money for it, was at Wheeler's, on Seventh street, where he could get a cent and a half a pound. He gave Robinson the stock because he wanted him to act as one of the directors. Hassler also suggested Beach. In "his impudent card" Beach said the doctor had introduced himself. Possibly he had sent in his card with a statement that he would send him a pamphlet. "I sent him some jingles," said the doctor; "I write jingles and said I would try to bribe him with a poem."

The doctor then referred in indignant language to the conduct of a Washington editor, who, he said, had refused to publish a card in answer to a card of Mr. Beach which had appeared in the same paper. The doctor had sent stock to Mr. Cox, who had replied, asking for the poem that he had failed to inclose. "I believe that if I had sent it, he would have come in."

He had offered $100,000 in stock in the Pennsylvania company to Mr. Randall, who had replied courteously that he knew nothing about the matter, and intimated that he wanted to hear more. He made the same offer to Mr. Carlisle, who had replied in a very respectful letter that if there was any legislation connected with the affair he could have nothing to do with it. He wanted Randall and Carlisle in the Pennsylvania company to give prestige to the stock. He had merely written to these gentlemen that he would simply credit them in the books with the stock. Mr. Cox had replied that he did not think the stock was worth anything or the witness would not be sending it around so fluently, and his clerk had returned the stock to his office. The doctor had given away millions of stock, had offered it every day, but he was "as poor as Job's turkey." Looney, however, had informed him that a banker stopping at the Ebbitt House would give $17,500 for the doctor's stock.

The doctor then explained that his political affiliations had always been with the Democratic party, and most of his friends belonged to that party. A bank clerk had told Father Rochefort, "There is only one thing you want to make that stock go—put Jeff. Davis on it."

In answer to questions, he declared that he had no idea, when the company was organized, that Mr. Garland would be attorney-general; but had done his best to make him attorney-general after Cleveland's election. He had dedicated a book to attorney-general Garland, and predicted that Cleveland would select the wisest, purest man in the country to elevate the judiciary of the country; that was two months before Garland had been made attorney-general. He had no idea of using Mr. Garland's influence to promote Pan-Electric interests except in so far as his name might be rendered more illustrious. The Pan-Electric had filed a suit in Memphis against the Bell company, and he had seen the bill which had been prepared by Mr. Gantt, but did not know what had become of that suit. On the 24th of May he had sent a letter to attorney-general Garland asking him to institute a suit against the Bell company. He had noticed in the papers the fact that attorney-general Brewster had directed proceedings to be begun in a similar suit involving the validity of a cotton-tie.

Prior to that time nothing had been said by any member of the Pan-Electric company in regard to the suit. The idea originated with Dr. Rogers. Seeing this article published, it occurred to him that if Brewster had done it Garland might do it. He did not receive any reply from Garland. Young acknowledged the receipt of his letter to him, and said that he thought Garland might feel a delicacy about it.

The doctor talked with his son very often about the government bringing suit. He talked with Young once about it, and he said that George Gantt had found many precedents for it.

The chairman—Did you ever have a conversation with Senator Harris about bringing suit?

The doctor—Never; I wrote to him and received no reply.

The chairman—Do you remember Young's having come to your house and told you and your son of an interview with Garland?

The doctor—Perfectly. He said that the suit would now be brought and there were good prospects of success. I asked if Garland had promised, and he said that he had.

The chairman—How did you come to ask him?

The doctor—I thought it would have to come through a promise of Garland's.

The chairman—Did Young indicate that he had had an interview with Garland?

The doctor—Yes, I think so; it was predicated on that. When he said that Garland promised, I said, very emphatically: "If Garland has promised, he will do it." Then Young said: "But Garland has said he will refer the matter to Mr. Goode." "Then," said I, "how about that? How would Goode act? Would he do as well as Garland?" "Oh, yes," said he, "I believe I would rather have Goode than Garland; he will be all right." That is the substance of the conversation.

The chairman—Are you clear that he told you Garland had promised?

The doctor—Just as clear as that I exist. I stake my salvation on it, because I rose up and said: "If Garland has promised, he will do it." I was delighted, of course.

In answer to further questions by the chairman, the doctor denied that any Pan-Electric stock was pledged to the Bell company. He had been told that the Bell company had offered to buy Young's stock, but that Young would not entertain the offer. That was the only whisper he had ever heard about it.

The chairman—Has anything been said to you by an official of the Bell company or by any person assuming to speak for it, with regard to the general controversy?

The doctor—No, sir.

The chairman—Has any person, other than gentlemen of the press, said anything to you about furnishing matter for publication?

The doctor—Never.

The chairman—Have you ever received anything for information?

The doctor—Never one farthing, either from any paper or the Bell telephone, or anybody else God ever made.

The chairman—Why did you furnish these letters?

The doctor—On account of an article in the *World* which represented me as being head devil in a kind of Oakes Ames Credit Mobilier affair, and which represented senators and congressmen associated with me as being the dupes of me and my son.

The chairman—Did you furnish this material with a view to vindicating these gentlemen or attacking them?

The doctor—First of all, to vindicate myself, and collaterally to vindicate them. In order to vindicate myself, I had to vindicate them.

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The doctor then detailed the causes which had impelled him to give publicity to the letters, and said: "When I thought my son was to be crushed into the mud, I intended to defend him at all hazards compatible with his honor and my own."

Recurring to the conversation held with Young in his room about the government suit, he said Young had told him that the other parties—the National Improved Co.—had collected $75,000 worth of testimony in Europe, and they were desirous of a combination in the suit, so as to put that testimony against some little influence that they (the Pan-Electric people) might have. That was about two weeks before the institution of the government suit. It was stated that the suit would be brought in the name of that company, but witness did not know the reason. Witness had been a party to the National Secret Telephone Co., organized two years before the Pan-Electric, by Messrs. Hine, Hume, Dean and Gen. Thomas Ewing, of Ohio. The capital was $5,000,000, based on his son's inventions. That company had leased the Pittsburg and New Orleans companies. Van Benthuysen had been the organizer of the New Orleans company—the National Improved Telephone Co. He had sold out his stock in the Secret Telephone Co.

The doctor was then requested to state the transfers of Pan-Electric stock or Pan-Electric Telephone stock made by himself. He replied that he gave Looney a sixth interest in the Pan-Electric company, but as there was no stock, of course there were no transfers. After telephone and telegraph patents had been taken out, Looney had gone out with the certificates and made sales to individuals. Sales had been made to Mr. Neily, Col. Boyle, Jacob Thompson and Dr. Watson, of which he got one-half the proceeds and Looney the other half. He had made other transfers to his wife, to Thomas Mitchell and Mr. Dean or Mr. Ewing. Had no transactions of any kind with a man named Cummings that he could remember. Had been introduced to a Mr. Cummings some four or five years ago, but had never seen him since, and was positive that he had received no money from him. Mr. Money had retained the Rogers telephone stock and the American Postal stock, and he believed his letters would be found in the correspondence put in evidence.

He had never sold any stock to a member of congress and knew of no sales of that kind, unless it should appear that a man named Howard, who had bought some stock, had been a member of congress.

In the case of the New York company—the Postal company—he had offered stock to Messrs. Cox and Beach rather than to Mr. Ranney, because the first-named gentleman lived in New York and he had designed the stock to be floated in the New York stock market, while Mr. Ranney lived in Massachusetts.

"Did you tell your associates about your sales of Pan-Electric telephone stock?" inquired Mr. Ranney.

"I didn't conceal anything," replied the witness. "Whatever I did was done on the housetops. But that was my private business."

Mr. Ranney wished to know why the witness had selected members of congress as recipients of stock.

"Oh, I did not distribute this stock with a view to corrupt these great men in either house of congress."

Continuing, he said that he had selected congressmen rather than prominent business men because they had a wider reputation as a rule.

He corroborated his son's statement that no money had been received for the letters published in the newspapers. Of the Rogers Telephone Co. the witness said that while it was an independent organization, yet it had been connected with the Pan-Electric. "I transferred to that fictitious body—that named the Rogers Telephone and Telegraph Co.—a million dollars' worth of Pan-Electric stock. Then the Rogers company was bound to pay a royalty to the Pan-Electric for every set of instruments used."

Mr. Ranney then took up the pamphlet put in evidence, and questioned the doctor as to his personal knowledge of the statements touching the institution of the government suit and Van Benthuysen's connection with the same.

He said that most of the statements had come to him through third persons.

Reference was made to a statement in the pamphlet that Van Benthuysen became convinced at the Ebbitt House conference that the interior department might report adversely, and that if he withdrew the application and signed a certain agreement a direct order from the department of justice would be issued to bring the suit and thus forestall an adverse decision of the interior department.

Mr. Ranney wished to know the ground for the statement.

The doctor replied that it was a probability. He believed that Van Benthuysen, Young and Garland all understood perfectly well that suit was to be brought in a short time.

Dr. Rogers closed his testimony on Friday, March 19, by adding the following names to those whom he had previously mentioned as receiving stock:

Gen. Frank Armstrong (of the Indian office at that time), Gen. Thomas Crittenden, Gen. A. B. Upshaw (now of the Indian office), Col. Boudinot, R. C. Wintersmith, A. D. Cooke and the *Republican* and *Chronicle* (Washington newspapers). He sold the stock to the newspapers; gave it for advertising. Most of the stock was of the Rogers Telephone and Telegraph Company. Possibly he had given American Postal stock to Messrs. Money and Manning. He had expressly contemplated legislation for the American Postal Company, and it was so stated in the pamphlets, but the bill was never introduced.

He would have given Mr. Cox more than he had offered, because he was an illustrious man, and his name stood like the sun in the heavens, and he would have helped the doctor sell his stock. He did not think $1,000,000 of stock would seduce Mr. Cox. Saw no impropriety in giving stock to members. "Congressmen do not take vows of chastity, poverty and obedience," said he. "I went upon that principle," he added, to the amusement of the spectators.

The doctor also corrected his previous testimony regarding the stock transferred to Looney, saying that Looney had paid for his Pan-Electric interest with Indus mining stock, that afterwards proved to be worthless.

UNDERGROUND AGITATION IN MASSACHUSETTS.

The following testimony has been taken before a committee of the Massachusetts legislature in regard to placing electric wires underground.

Hon. T. J. Gargan appeared for certain property owners in Boston who desire such legislation, and said that the wire nuisance has increased to a dangerous point, and the overhead wires are so numerous that they are in the way of the fire department, obstruct the light in many narrow streets, and in case of gales endanger life and property. It is time that the corporations should be required, out of regard to the public safety, to place their wires underground in Boston, as is being done elsewhere. He submitted to the committee a bill requiring the appointment by the governor of a special board of three commissioners, to be paid by the companies, with power to require the companies to place the wires underground as rapidly as may be.

Mr. Henry C. Spaulding, of Boston, was called by Mr. Gargan as his first witness, and said he represents capitalists who, last year, asked authority to lay trunk lines of wires underground for long distances across the state, and desire legislation to prevent local authorities from refusing a location or establishing too onerous conditions, and to allow the proposed company to cross private property to a limited extent where the nature of the ground or other local circumstance requires such an easement. Until this leave to cross country is granted, he protests against compelling the companies to put their wires underground in the cities only. At this point Mr. Gargan stated that he misunderstood Mr. Spaulding's position, and does not claim him as a witness.

Alderman William P. Carroll was next called by Mr. Gargan, and described the havoc produced among the electric wires on Albany street by the recent gale. He thought the companies should be compelled to make a repetition of such accidents impossible, by putting the wires underground. He differed, however, from Mr. Gargan as to giving the matter in charge of a state commission. Mr. R. M. Morse, Jr., said that the telephone companies have already put 300 miles of wire underground in Boston.

Mr. Parker C. Chandler appeared for the Baltimore & Ohio and Mutual District companies, and reasoned that the legislature of Massachusetts should await the result of the costly experiment now going on in New York before digging up the streets of Boston. City solicitor Bailey appeared in advocacy of the principle of compulsory legislation of the subject, but against state supervision of the subject. Mr. Peter A. Dowd, a telegraph constructor, said that it is now perfectly feasible to run wires underground a distance of two or three miles, as is already successfully done in New York, Washington, Chicago and elsewhere. The service would be better and more economical, but not enough so to induce the companies to assume the heavy first cost of the change. All wires except the telephone can be put underground for indefinite distances, but for telephone wires it would be difficult, with present appliances, to maintain underground currents beyond, say, a radius of two miles.

Mr. Bailey said that the companies argued before the aldermen that it would be physically impossible to lay the Friend street wires underground, but the aldermen ordered the poles removed notwithstanding. Then the companies asked leave to lay their wires underground, and did so, and the arrangement has worked well. When the law requires all wires to be laid underground, electrical science will rise to the emergency, and it will not before. The city of Boston is ready to lay the fire-alarm wires under as soon as it has power to require other corporations to do the same.

Thomas D. Lockwood, electrician of the American Bell Telephone Company, appeared as an expert. He said that there were not nearly so many wires underground as some suppose. In Europe there are buried wires in London and Paris. In the latter city the large sewers were utilized for telegraph and telephone wires; the few buried telephone wires have a special return wire

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twisted around the main wire, which is called the metallic circuit. In London none of the telephone wires are underground. The cities of the United States in which there are buried wires are Boston, New York, Pittsburg, Washington and Chicago, but no person would know they existed in either, there being no apparent diminution of the overhead wires, even in Chicago, where all are said to be buried. The American Bell Telephone Company have now nearly 300 miles underground, of which about 75 miles were laid last year. In New York burying the wires was found to be four times as expensive as placing them on poles, and the labor is four times as great. In both New York and Pittsburg there are only short lines. Washington is more practically situated for underground wires than most cities, being self-contained, and about one-sixteenth of its wires are buried. Mr. Lockwood proceeded to explain in a very interesting manner the electrical obstacles to underground wires, the expense incident to which would be enormous. One item of expense would be the necessity of return wires, and instead of 2,000 wires entering the central office in Boston, there would have to be twice that number. There are 467 patented processes for burying wires, each of which is owned by a corporation; but none of them are able to overcome the obstacles he had mentioned. He suggested that the committee defer action until the result of the New York commission of inquiry is ascertained. The system of the future would be a mixed one, partly underground and partly overhead. If the electrical obstacles could be overcome the telephone companies would not demur at the expense of burying the wires. To Mr. Gargan Mr. Lockwood said if we had such a system of sewerage in Boston as that of Paris there would be no objection to a similar system of carrying wires underground.

Mr. W. D. Sawyer said that in laying telegraph wires on Friend street, the company found it cheaper to lay their wires underground than to carry them over the roofs which were offered to them for nothing.

Mr. John A. Coleman, mechanical engineer, said if we would do as they do in Paris, there would be no trouble worth mentioning. The system of putting a pipe underground and covering it up is a relic of barbarism. He argued that although the present telephone wires cannot be buried to advantage, there are wires in existence which can be used without difficulty.

SUBTERRANEAN TELEPHONE CONSTRUCTION IN BROOKLYN.

The New York and New Jersey Telephone Co. has made arrangements to begin a considerable amount of underground work about the 1st of May.

A conduit will be put down leading from the Brooklyn exchange through Myrtle and Nostrand avenues and Lynch street, to the Williamsburgh office corner of Broadway and Boerum street, a distance of about 3¼ miles. This will be of the Dorsett system, similar to that now used in Chicago and Detroit. It will contain ten 2½ inch ducts. Favorable reports regarding this conduit from the cities where it has been used, have led to its adoption for this route, with a view to giving it a practical test. It has also been adopted by the American Telephone and Telegraph Co. for its Philadelphia connections.

The conduit manufactured by George Richardson, of Philadelphia, will be used in the construction of a branch from Fulton street through Nostrand avenue to Bergen avenue, thence to Prospect place, a distance of 2400 feet. This pipe will be of two and four ducts, each two inches in diameter. The line connects the main office, Brooklyn, with the Bedford avenue exchange. The Richardson conduit is made of artificial stone, composed of cement and sand, treated to a carbonizing process, which gives it unusual strength and durability. It has been used a long time for sewer pipes, and its evident adaptability for subterranean electrical work has led to its being subjected to this practical test.

Nearly 2½ miles of creosoted wooden conduit have already been laid down in Brooklyn. These contain from four to ten ducts, the largest size of the box being 10" x 18". The route already covered extends from the main office at 397 Fulton street, north and west, to the test room near Fulton ferry, where it meets the cables from New York over the East river bridge. Another branch extends from the main office down Court street to Atlantic avenue where it branches both ways.

A main line has also been laid in Fulton street from number 397 to Raymond, with branches at De Kalb, Flatbush and Third avenues to Atlantic avenue. This main is to be extended from Raymond to Marcy avenue taking in the Bedford avenue central office, and having branches at Raymond street, and Greene, Clermont, Waverly, Classon, Bedford, Nostrand and Marcy avenues.

Another line of creosoted wood conduit will begin at Reid avenue and Broadway, Williamsburgh, connecting there with the Dorsett conduit and extending to the foot of Broadway, at East river, and another branch up Union avenue, toward the Greenpoint central office, to which it will finally be extended. Another main line of creosoted wood with branches will be laid in Nostrand avenue, from Fulton through to Myrtle. As the Fulton and Nostrand avenue line will join the Myrtle avenue conduit, the three exchanges—Brooklyn, Bedford avenue and Williamsburgh, will be connected with each other by a subterranean system, communicating with New York by the trunk wires over the bridge. This will make a total length of over 14 miles, which superintendent Reilly says will make "as complete and comprehensive system of underground work as we know anything about." It is the intention to finish the work during the coming summer. The Brooklyn subway commission has given its consent to the construction of these conduits, in order to facilitate the work, although this does not imply the special endorsement of any of the plans adopted.

WESTERN UNION SCRIP DIVIDEND.

The Western Union Telegraph Co., declared a quarterly dividend yesterday of 1½ per cent., payable in scrip. The scrip will be issued on and after April 15, to stockholders of record at the close of business on March 20. The scrip is exchangeable within 12 months at par for stock, or whenever the company shall have obtained the necessary authority to increase its stock, and until so exchanged the scrip will be entitled to the same rate of dividends as may be paid upon the stock. The statement submitted by the directors of the business for the quarter is as follows:

Surplus Oct. 1, 1885		$4,230,958 87
Net revenues quarter ended Dec. 31, 1885		1,014,559 01
Total		$5,245,517 88
From which, deducting appropriations for—		
Dividend of 1¼ per cent., paid Jan. 15	$999,875 34	
Interest on bonded debt	123,462 70	
Sinking funds	20,000 00	
Total	$1,143,338 04	
Leaves a surplus Jan. 1, 1886, of		$4,102,179 84
Net revenues of quarter ending March 31, based upon nearly completed returns for January, partial returns for February, and estimating the business for March, will be about		1,050,000 00
Add surplus Jan. 1, as above		4,102,179 84
Total		$5,152,179 84
From which appropriating for—		
Interest on bonded debt	$123,500 00	
Sinking funds	19,991 00	
		$143,491 00
Leaves a balance of		$5,008,688 84

The managers of the company attribute the unfavorable showing to the decrease in cable, commercial news, and quotation service, together with increased expenses for taxes and repairs, both upon the land and cable lines.

DECISION IN THE RUBBER PACKING SUIT.

The long delayed suit of the New York Belting and Packing Co. *versus* Allan Magowan, for an infringement of their well-known vulcanized rubber back packing, has been recently decided in favor of the company. In his decision, after some pertinent compliments to the ingenuity of the inventors, Judge Dixon declared that "after carefully comparing it with the exhibits which are put in to show anticipation and its lack of patentability, I am of the opinion that the patent reveals invention; not so much because the packing is more elastic by reason of the addition of pure rubber, but because the patent discloses a new and better method of obtaining a tight joint between the padding and the piston rod, than has been obtained by any other combination of elements, new or old. It is a fact not to be overlooked, and has much weight, that the products manufactured under it, went at once into such extensive public use as to almost supersede all packing made under other methods. Such a fact is pregnant evidence of its novelty, value and usefulness, and accounts for the defendants' infringement."

THE ESSICK PRINTING TELEGRAPH.

An exhibition of the printing telegraph system of S. V. Essick, was given by the National Printing Telegraph Co. at 145 Broadway, on March 6th. The instrument differs from those in ordinary use by the recording of the message in page form upon paper about three inches in width, instead of a single line on a narrow tape. The alphabet is arranged upon the type-wheel in two rows in order to lessen its diameter. The transmitting and receiving instruments are combined in one machine, and possess several ingenious features which are worthy of the attention of those who are interested in this branch of telegraphy. It is intended for use on private lines or in general commercial telegraphing.

ELECTRIC LIGHT AND POWER.

After two months' careful deliberation, the special light committee of Wooster, Ohio, has awarded the contract for street illumination to the Schuyler Electric Light Co., of Hartford, Conn.

The municipal authorities of Mobile, Ala., have accepted the bid of the Brooklyn Electric Lighting and Construction Co., to furnish a plant and machinery complete, that will be placed in the

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market on Royal street, and is expected to be in operation within three months.

The Western Edison Electric Light Co. have recently contracted and are placing the following plants: Crane Bros., Manufacturing company, 200; J. V. Farwell & Co., 250; the Eisendrath tannery, 150; William Deering & Co., 500; Northwestern Mutual Insurance Co., at Milwaukee, 1,200; town of Brodhead, Wis., 150; Pitkin, Vaughn & Co., 250; town of Neillsville, Wis., 150; Southern Hospital for the Insane at Anna, Ill., 650; Mannegold & Son's mill at Milwaukee, 50; Taylor Bros. & Co.'s mill at Quincy, Ill., 100; Two Rivers Manufacturing Co., at Two Rivers, Wis., 300; Phister & Vogle Co., Milwaukee, 300; Heinemann Brothers, Wausau, Wis., 60: Lindell Hotel, St. Louis, 350, and the Anhauser Barsch Brewing Co., St. Louis, 1,000.

The Windsor Hotel, New York city, is now beautifully lighted by a 500-light installation, on the Westinghouse system. The vestibules are illuminated by single lamps of 150 candle-power each.

Raleigh, N. C., is to be lighted by the Thomson-Houston system, backed by a Westinghouse engine.

Among recent electric light customers, the Westinghouse Machine Co. report: Portsmouth, Ohio, 60 h. p.; J. C. Reagan, Omaha, 60 h. p. (third order); Kuhn & Bro. and T. C. Jenkins, Pittsburg, each 85 h. p.; Adams Express Co., Philadelphia, 25 h. p.; Des Moines Electric Light Co., four of 60 h. p. each; Moberly Electric Light Co., Moberly, Mo., two of 45 h. p.; Anheuser-Busch Brewing Co., St. Louis, Mo., 100 h. p.; Windsor Hotel, New York, 60 h. p.; Thomson-Houston Electric Light Co., Raleigh, N. C., 60 h. p.; Town of Union Silk Mill (second order), Union Hill, N. J., 60 h. p.; Allegheny County Electric Light Co. (ninth and tenth orders), Pittsburg, two 75 h. p.; Jas. Doak, Jr. & Co , Worsted Mills, Philadelphia, Pa., one 45 and one 15 h. p.

Westinghouse, Church, Kerr & Co., engineers for the Westinghouse Electric Co., have, within the last sixty days, contracted for the following installations: Allegheny County Light Co., 2,000 lights; Trenton Electric Light and Power Co., 1,000 lights; Union Depot, P. R. R. Pittsburg, Pa., 1,000 lights; Windsor Hotel, New York, 500 lights; Monongahela House, Pittsburg, Pa., 400 lights; East End Hotel, Pittsburg, Pa., 300 lights; T. C. Jenkins, Pittsburg, Pa. 300 lights; Morrison, Beare & Cass, paper mill, Tyrone, Pa., 300 lights; Wheeling Steel Works, Wheeling, W. Va., 100 lights; Jas. Doak, Jr. & Co., worsted mill, Philadelphia, 200 lights; steamer *Newburgh*, 100 lights; steamer *Fishkill-on-Hudson*, 25 lights; and a number of small plants.

MANUFACTURING AND TRADE NOTES.

W. L. Libbey & Son, of the New England Glass Works, have been granted a preliminary injunction against the Mount Washington Glass Co., for the infringement of the patent on "Amberina" glass. In this form of glassware the articles are of two colors, one of ruby, the other of amber, shading into each other and producing a beautiful effect.

About May 1st, the Electric Mfg. Co., of Troy, move their office and factory to their new brick building at Greenbush, where they will enjoy greater facilities for their growing business.

PERSONAL MENTION.

Mr. Frank L. Pope and wife, returned from Europe by the steamer *Gallia*, arriving in this city March 2. They derived much pleasure from their trip, although the latter part of the home voyage was unusually rough.

General manager W. D. Sargent, of the New York and New Jersey Telephone Co., who recently sailed to Nassau, N. P., on a trip for the benefit of his health, arrived there March 8th, and is expected home about the middle of April.

SUBTERRANEAN LINES.

The Brooks Underground Conduit Co., of Philadelphia, has made a proposition to the councils of that city to bury at its own expense the necessary wires for all purposes, public and private, and maintain them between the Delaware and Schuylkill rivers from Vine to South streets.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICIAN AND ELECTRICAL ENGINEER, *by* Pope & Edgecomb, *Solicitors of Patents for Electrical Inventions*, 11 *Wall Street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From January 26th, to March 9th, 1886 (inclusive).

Alarms and Signals:—*Call-Box*, J. H. La Bau, 334,785, Jan. 26. *Leak Detector for Gas*, I. M. O'Donel, 314,890; H. C. Bauman, 337,116, March 2. *Fire-Alarm Box*, T. F. Gaynor, 335,025, Jan. 26. *Fire-Alarm Telegraphy*, same, 335,026, S. J. Sanford, 337,439, March 9. *Fire-Alarm Signal*, T. F. Gaynor, 335,027, Jan. 26. *Fire-Bucket Low Water Alarm*, C. J. Hexamer, 335,223, Feb. 2. *Call System for Hotels*, J. C. McLaughlin, 335,604, Feb. 9. *Call Generator*, E. T. Gilliland, 325,693. *District Call Box*, F. A. Holcomb, 335,701. *Magneto Bell*, F. E. Fisher, 335,999. *Call Box*, D. Davis, Jr., and G. F. Gale, 337,356, March 2. *Signaling Apparatus*, H. Thau, 335,852, Feb. 9; E. T. Gilliland, 336,562, Feb. 23; A. G. Holcombe, 336,643, L. Sellner, 337,626, March 9. *Annunciator*, F. E. Fisher, 336,001, Feb. 9. *Push Button*, same, 336,003. *Thermostat for Incubators*, J. C. Losee, 336,125, Feb. 16. *Magneto Door Pull*, W. Humans, 336,518. *Alarm for Water Overflow*, L. Weil, 336,773, Feb. 23. *Attachment for Fire Alarm Boxes*, H. H. Rebbeck, 337,198, March 2. *Mail Box and Indicator*, H. F. Staus, 337,796, March 9.

Clocks:—J. E. Carey, 334,745, Jan. 26. *Device for Winding*, W. F. Sweet, 334,822. *Clock System*, F. E. Fisher, 336,004, Feb. 9, C. D. Warner, 335,860. *Alarm Clock*, C. Korfhage, 337,067, March 2. *Regulator for Pendulum Clocks*, S. Eastman, 337,385, March 9. *Secondary Clock*, V. Himmer, 337,588. *Means for Regulating Pendulum Clocks from a Distance*, G. W. Millard and J. H. Clarke, 337,416, 337,417, 337,418, 337,419. *Self-Winding Clock*, D. F. Sweet, 337,797.

Commutators:—*Switch*, C. F. Brush, 335,269, Feb. 2; E. Thomson, 335,548.

Conductors, Insulators, Supports and Systems:—*System of Laying Conductors in Building*, C. N. Fay, 334,763, Jan. 26. *Insulating Cables*, R. A. Denison, 334,850. *System of Electrical Distribution*, F. J. Sprague, 335,045, Jan. 26; S. S. Wheeler, 335,048, 335,099. E. Thomson, 335,159, Feb. 2. *System of Lighting*, H. M. Doubleday, 335,060, Jan. 26; R. Mackie and N. McCarty, 337,004, March 2. *Underground Conduit*, T. A. B. Putnam, 335,091, Jan. 26; J. J. Schillinger, 337,624, March 9. *Cable Conduit*, W. A. Wright, 335,553, Feb. 2. *Composition for Insulating Wires*, W. J. Rigney and J. Wolff, 336,018, Feb. 9. *Insulator*, J. Wilson, 336,276, Feb. 16; C. L. Travis, 336,828, Feb. 23. *Conductor*, H. A. Clark, 336,992, March 2. *Circuit for Lighting*, R. Mackie, 337,005. *Communicating System for Hotels*, A. G. Holcombe, 336,809, Feb. 23.

Dynamo Machines and Motors:—*Commutator for Dynamo*, N. Tesla, 334,823, Jan. 26. *Armature for*, H. R. Boissier, 335,105, Feb. 2; C. F. Brush, 336,087, Feb. 16; F. Bain, 337,042, March 2; C. Coerper, 337,558, March 9. *Device for Transmitting Power*, E. H. Johnson, 335,285, Feb. 2. *Dynamo*, W. L. Voelker, 335,325, 335,326, Carl Hering, 335,355, J. M. A. Gerard-Lescuyer, 336,636, Feb. 23; R. E. Ball, 336,780, F. Bain, 337,041, March 2. *Motor*, E. Thomson, 335,547, Feb. 2; F. J. Sprague, 335,781, 337,793, 337,794, Feb. 9; J. Weis, 335,868, F. E. Fisher, 335,998, L. Daft, 336,629, Feb. 23; O. P. Loomis and H. W. Cooley, 337,775, 337,776, 337,777, March 9. *Regulator for Dynamo*, C. J. Van Depoele, 335,659, Feb. 9; J. E. Watson, 336,608, Feb. 23; N. Tesla, 336,961, 346,962, March 2; O. B. Shallenberger, 337,628, March 9; R. H. Mather, 337,778. *Magneto Machine*, F. E. Fisher, 336,002, Feb. 9. *Circuit Connection for Dynamos*, N. McCarty, 337,010, March 2.

Electrolysis:—*Apparatus for Forming Sheet Metal by Deposition*, M. G. Farmer, 335,905, Feb. 9.

Galvanic Batteries:—F. L. Lathrop, 334,788, Jan. 26; A. H. and A. W. Roovers, and P. G. Williams, 336,352, Feb. 16: H. J. Brewer, 337,477, March 9. *Cell for Battery*, J. W. Carter, 337,045.

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Telephone Systems and Apparatus:—*Transmitter*, J. F. McLaughlin, 335,294, Feb. 2. A. K. Keller and E. H. Lyon, 335,364, W. Burnley, 335,501, 335,502, N. Dowling, 335,510, 335,511, H. Alabaster and T. E. Gatehouse, 335,791, Feb. 9; W. P. Freeman, 335,806, C. A. Bell, 336,081, 336,083, Feb. 16; S. Tainter, 336,173, H. S. Thornberry, 336,268, W. C. Turnbull, 336,876, 336,877, Feb. 23. *Mechanical Telephone Diaphragm*, W. Taylor, 335,321, Feb. 2. *Telephone Circuit*, T. B. Doolittle, 335,436. *Telephony*, J Houlehan, 335,522. *Telephone System*, C. A. Jackson, 335,588, Feb. 9. *Automatic Exchange System*, T. D. Lockwood, 335,708, *Signal System for Exchanges*, W. S. Johnson and C. L. Fortier, 335,934. *Call Bell System*, F. E. Fisher, 336,000. *Jet Microphones*, C. A. Bell, 336,082, Feb. 16. *Individual Signal*, A. W. S. Davis, 336,095. *Method and Apparatus for Transmitting, Reproducing and Recording Speech*, C. A. Bell, 336,203. *Mouth Piece for Transmitter*, G. L. Lavery, 336,329, Feb. 16. *Looping-in Switch*, E. T. Gilliland, 336,563, Feb. 23. *Mechanical Telephone*, A. W. Hall, 336,640, R. O. Middleton, 336,731. *Telephone*, C. A. Randall, 336,744, Feb. 23. S. Bergmann, 337,231, 337,232, March 2; T. A. Edison and S. Bergmann, 337,254. *Call*, J. C. Wilson, 336,972. *Diaphragm for Telephone*, N. Dowling, 337,753, March 9.

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THE ELECTRICIAN
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NEW YORK, MAY, 1886.

AMERICAN GOODS IN FOREIGN MARKETS.

THE manufacturers of electrical instruments and supplies have never figured very prominently in the tariff agitations with which the country is periodically afflicted, consequently the relative merits of a protective, or free trade policy in its bearing upon their welfare has received little or no attention from the electrical press.

It is doubtless assumed that this industry requires no special legislation, but that those engaged in it share in the general prosperity which is supposed to accrue from the existence of a protective tariff.

Without thoroughly examining the subject it may be roughly stated that importations have been confined to gutta-percha cable, iron and steel wire, and wire rods, special forms of testing apparatus, and bichromate of potash. Exports to European countries have been considered as limited to special articles, which by reason of patents or patented processes are not yet manufactured abroad on account of the limited demand beyond our borders. It has recently come to our knowledge, however, that regular shipments are being made to Belgium of steel and iron screws, sheet brass and brass rods, and even iron castings, the latter being brought to the seaboard by rail from Ohio. This is not because of any special advantage in pattern or quality, but simply for the reason that the goods mentioned can be purchased here and laid down in Belgium at a lower price than they can be manufactured there. In the case of steel screws, it is perhaps proper to note that these are made from English Stub's steel which is subject to a heavy duty, and they are consequently produced at an additional disadvantage. These materials are used in Antwerp in the manufacture of electrical instruments under the supervision of a gentleman formerly engaged in the same business in this city, and who is, therefore, thoroughly qualified to profit by his familiarity with the markets in both countries. Various other goods are exported through the same channel, but not being classed as electrical in any proper sense their enumeration is not within the province of this inquiry. It is generally considered that Belgium is or ought to be the manufacturer's paradise, so far as cheap skilled labor is concerned, and it is for this reason that we direct attention to this matter as of special interest to those who have no faith in the ability of American manufacturers to compete on their merits with those of the old world.

It is not our purpose to attempt either to prove or disprove the theory that this state of affairs has been made possible by a protective tariff, but to simply narrate the facts in support of a belief which we have long entertained, that the skill of our artisans, the perfection of our automatic and labor-saving machinery, combined with the natural resources of the country, would enable us to hold our own in the markets of the world under any circumstances without artificial restriction or stimulation. If this has not been the case in the past, we certainly are rapidly approaching such a state of affairs in respect to many lines of manufactured articles.

An English gentleman of our acquaintance, who visited various factories in New England three years ago, in conversing with the different proprietors, discovered the curious fact that while almost every one of them individually announced his belief that a protective tariff was not essential to the prosperity of his particular business, he thought that it was a good thing for his neighbors, if not necessary to their commercial existence.

A thorough examination into the relative market prices of similar grades of manufactured goods of different kinds at home and abroad would doubtless show still more interesting facts than we have been able to present from the limited amount of information at hand. It appears to be the fact, that as a people we have grown up in the belief that the general prosperity of the country is based upon a system of artificial protection. This hallucination has been supported in many instances for political ends by men who really do not believe the doctrine they advocate. It is time it was discussed in a more rational manner.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

THE second annual meeting of the Institute for the election of officers will be held on May 18th, and, following the precedent of last year, the general meeting for the presentation and discussion of papers will probably take place on the succeeding day.

The papers already promised cover a wide range in the electrical field, and there is no doubt that the occasion will be exceedingly interesting and instructive.

Among other subjects to come up will be: Recent Progress in Telephony; Incandescent Lighting from Central Stations; Secondary Batteries for Light and Power; Patent Office Practice; Subterranean Electric Systems; and the Static Difficulties in Multiplex Telegraphy. These topics in themselves are amply sufficient to occupy the attention of members during the sessions, but the officers will gladly entertain the consideration of other papers

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which properly come within the province of the Institute.

The importance of awakening general interest in these matters should be thoroughly appreciated, and receive the ardent support of all who are engaged in electrical pursuits.

It can scarcely be expected that a young society should at once leap to the prestige attained by similar bodies in other professions, but it must be remembered that electrical engineering has not as yet attained that public recognition to which it is properly entitled. Whether it will in the future, depends in a great measure upon the efforts of those who are now engaged in its practice. It will not do for each one to depend upon the efforts of some other person, but individual enthusiasm must be directed toward the general advancement of the good work.

It is too frequently the case that those who are the best qualified to foster the growth of a scientific society are so fully occupied by the exactions of a busy life that they cannot spare the necessary thought and time required for the encouragement of organizations which promise no immediate financial return.

This is a matter which concerns every person who believes that the field of electrical industry has a promising future, and who intends to continue his identification with it. When we consider the fact that a thorough electrical engineer should be familiar not only with the theory and practice of his own profession, but of mechanical engineering as well, we should recognize the importance of his attaining a standard befitting the character of the duties which he may be called upon to perform.

In view of the short time it has been in existence, the Institute has been exceedingly fortunate in placing before its members many important papers, leading to very interesting discussions, which have been preserved in the published proceedings.

In this respect the coming meeting should be still more successful, and every member should do his part toward effecting that most desirable result.

THE ARC-LIGHTING INDUSTRY.

THE most favorable indication of the permanent prosperity of the electric lighting industry is the fact that it is quietly settling down upon the basis of ordinary commercial undertakings, and is now generally free from that artificial stimulus which was originally given it for the purpose of floating various speculative schemes. It appears now to offer inducements for the investment of a considerable amount of capital in the aggregate, which, under careful management, will earn a good profit. Once fairly established, a local electric lighting company advertises itself, and will secure customers, as it gradually evinces its ability to render good service.

It is but a few years since electrical knowledge was confined to those who were employed in the telegraph business, which required a large investment of capital. Under existing conditions, however, it is entirely possible for men of moderate means to organize small companies and engage in the electric lighting business in unoccupied fields with an excellent prospect of success. Considerable care ought to be exercised, however, in starting an enterprise of this character, as the margin of profit is small; but in the absence of competition a fair estimate of the probabilities may be made without incurring any great expense.

In order to give a correct idea of the points to receive consideration in establishing an arc-lighting system, as well as its proper management from a thoroughly practical standpoint, we have arranged for the publication of a series of articles which we are confident will not only serve as a reliable guide at the outset, but will give many valuable hints to those who have already had much experience in the business. It will, of course, be understood that with so many different systems in use, it would be difficult, if not impossible, to undertake to point out the good and bad features of each, even if such a task was consistent with the purpose of the writer. To avoid, so far as possible, any suspicion of favoritism, many interesting features which are controlled by patents must necessarily be either omitted, or accepted as an argument of more or less value in favor of the system with which they are identified. It is also understood that there are widely differing views upon certain points among men of equal experience and intelligence. These will naturally lead to criticism, and we should be pleased to receive from our readers any suggestions which would be of value in connection with this subject.

Electric lighting, although making great strides, lacks that experience of generations which leads up to the most economical methods of obtaining the best results. The attainment of this desirable condition may be greatly hastened by intelligent discussion, and this is one of the many important missions of the electrical press.

NOW IS THE TIME TO PLANT WIRES.

THE season of the year which is favorable to the beginning of underground work has fairly arrived, with no indications of such preparations having been made as will lead to practical progress before winter again sets in. Acting in the belief that nothing should be done until a plan was adopted which would accommodate all wires, the subway commission has refused to grant permits to companies who have desired to open the streets for the accommodation of their own wires only. It is believed in some quarters that this restriction will be modified sufficiently to permit the most important companies to proceed with their subterranean work according to the plans which they favor, and under the franchises which they have secured. The Edison company now owns an independent subterranean system, and if the Western Union Telegraph, and the Metropolitan Telephone companies should lead off, followed later by the Brush and United States Electric Light companies, in placing existing wires underground, there would not be much difficulty in providing some kind of a hole through the ground for those which remained. It is barely possible that the arc-lighting companies may be in a position to insist upon remaining above ground. If it was a question between dispensing with electric street lighting and burying the wires, the people would, no doubt, prefer to allow matters to remain as they are. In Brooklyn, where some progress is being made in underground work with the consent of the subway commission, no attempt has been made to

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provide for the electric light wires. The managers of all telephone companies would probably prefer to have them left as they are, rather than risk interference from them as subterranean neighbors.

In view of the fact that the distribution of electric light and power may be considered as still in the tentative stage, it would, perhaps, be wise to allow such wires to remain until it becomes necessary to rebuild them, without, of course, permitting them to become sufficiently decayed to be dangerous.

It would certainly be a curious termination of this whole business, if, while awaiting the perfecting of some inclusive system which would suit everybody, the individual companies should quietly bury the greater portion of their wires, leaving the proposed conduit company to wax fat on the "wild-cat" private lines which cannot undertake such work on their own account, or in lieu of paying tenants, to organize electric companies to occupy their space.

DEATH OF CHARLES E. LOEW.

Charles E. Loew, president of the New York Commission on Electrical Subways, died at his residence in this city, at three o'clock on the morning of April 21st, his forty-ninth birthday. While on his way to Atlantic City, nearly two months ago, he was attacked by pneumonia and returned home at once. He passed through the critical stage of that disease, only to linger with intense suffering from acute peritonitis until death brought relief.

Mr. Loew was born in Germany, in 1837, and was brought to this city while an infant. He was educated in the public schools, studied law, was admitted to the bar, and subsequently entered into politics, being elected county clerk in 1867 by a majority of 15,000, and re-elected at the end of his first term by a majority of over 60,000.

Mr. Loew's appointment as a member of the Commission on Electrical Subways, naturally led him to take great interest in the subject of underground electrical systems, and he frequently expressed his determination in the performance of his duties to do the very best possible thing for the companies interested as well as the public. He fully appreciated the difficulties of the problem which the commission was called upon to solve, and the thorough manner in which he investigated every plan submitted, convinced all that he was determined not to commit himself to any proposed system until all doubts as to its feasibility were thoroughly removed. While firm in his purpose, he listened patiently to all arguments, and maintained his position upon any question in so pleasant a manner that those with whom he disagreed were satisfied that he opposed them, not from obstinacy, but because he believed that he was right.

Had he not been incapacitated by his long and serious illness, it is probable that the preliminary work of the commission would have been brought to a definite conclusion before the date of his death, but under the circumstances his colleagues wisely refrained from entering upon the delicate duty of rendering a decision during his absence from the chair. According to the state law under which the commission was formed, any vacancy occurring in the board is to be filled by the governor.

THE QUESTION OF COMPETITION.

Among the more prominent topics brought up for discussion before the National Electric Light Association were those which are the legitimate fruit of competition. Its effect both for good and for evil, were perhaps brought out most prominently in the treatment of the subject of carbons. These very essential constituents of an arc lighting system were originally sold at $66.50 per thousand, whereas they may now be obtained at $10. It appears, however, that where cheapness means inferior quality, it is by no means economical to use the lowest grade. The loss arising from rebates on account of inefficient service, are sufficient to counterbalance any saving in first cost. It was also inferred that the quality of carbons was determined from an æsthetic rather than from a scientific standpoint. In this particular instance it is very probable that a cure will be effected, as soon as the manufacturers ascertain that deterioration in the quality of their goods means decreased orders. Although no public denouncement of any particular brand of carbons has been made excepting the general reference to price, it is not improbable that future legislation may take a more definite turn, and members of the association warned against the purchase of inferior brands. What is true of carbons, also holds good with other articles in the line of electrical supplies. Permanent and reliable work demands honest material, and those manufacturers who ignore this rule will eventually suffer for it. Purchasers are, however, to a considerable extent responsible for this state of affairs, and owing to the various deceptions practiced in trade it is exceedingly difficult to determine the exact location of the dividing line which exists between high priced articles of a good quality and low priced goods which are inferior. It is the exercise of careful judgment upon questions of this character that leads to either profit or loss in the management of an electric lighting plant or any similar business, where valuable property is entrusted to the hands of employés who generally treat inanimate matter as they are in turn treated by those who hire them. Electric light companies are, however, sellers as well as buyers, and find themselves called upon to furnish a marketable article at the lowest possible price, so that the entire field of competition is to be considered.

TELEPHONES IN INDIANA.

In spite of the newspaper predictions that the Central Union Telephone Company was merely bluffing in expressing the determination to relinquish the exchange business in Indianapolis, the management has proceeded deliberately to carry out the proposed plan, and hundreds of telephones have been removed from the offices of subscribers. This has had the effect of stimulating counter legislation, and Mr. Holman has already introduced a bill in congress, the object of which is to prevent the owners of patents, which are used for the benefit of the public, from withdrawing their service from any state, because of the regulation of their rates by state legislation. Meanwhile, the people who have become accustomed to the convenience of telephonic communication in the transaction of their business will, in many instances, be compelled to return to pre-existing methods, which will appear all the more primitive by contrast. All of this might have been prevented by careful investigation of the subject, which would have fully exposed the absurdity of attempting the enforcement of the ridiculous rate of $3 per month.

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ARTICLES.

ON TELEPHONY, AND THE OPERATION AND FUNCTIONS OF THE INDUCTION COIL IN TRANSMITTERS.

BY THOMAS D. LOCKWOOD.

(Continued from page 126.)

When the telephone is fulfilling the functions of a receiver, the operation, though analogous to that of transmission, is, as already stated, quite distinct; being, in fact, a magnetic variation effected by the electric changes occurring in a surrounding helix, which magnetic variation, as a natural consequence, results in a variation of the amount of attraction exerted by the magnet upon a vibratory plate mounted in front of it; whereas in the operation of transmitting, the magnetic variation is effected by the movements of the plate, and is utilized in the excitation of corresponding currents.

It is, however, instructive to note that although in both cases the strength of the magnet is varied, that variation is accomplished in two very different modes, and that inasmuch as both transmission and reception are inherent and indispensable functions of telephonic communication, both modes are inevitably present, and employed in the very earliest examples of the electrical transmission of speech.

The varying electrical impulses arriving from the distant station, circulate through the coil of the receiving telephone and round the magnet core. When passing in one direction, they strengthen the magnetism of the core, while when passing in the other direction they weaken it. The magnet exerts a steady pull upon the centre of the diaphragm, which increases and decreases in power as the magnet is strengthened and weakened, and this variation in attraction is in precise correspondence with the varying magnetism and the varying currents.

The diaphragm subjected to this varying attraction moves to and fro, maintaining this correspondence, and sets up air waves in front of it, which reproduce or copy the original sounds. The successive transformations of energy which we have to contemplate in these operations, and the rapidity with which they are performed, viewed as a whole, constitute, to my mind, one of the most graphic illustrations of the conservation of energy which the circle of the sciences afford; for in a single communication we see sound transformed into mechanical motion, mechanical motion into magnetism, magnetism into electricity, and electricity, traveling over the circuit, reverses the order of transformation, and is at the receiving station transferred back again, successively into magnetism, mechanical motion, and sound.

In its function as a receiver, the magneto telephone has always reigned practically without a rival. The best forms, however, which have hitherto been devised, have, when used to transmit, proved deficient in the power of generating currents of strength enough to reproduce words loudly.

As a transmitter, not only is its original force quite limited, but its effects are diminished by another cause, *i. e.*, the rise of a counter electromotive force in the circuit. We are comparatively familiar with other illustrations of this operation. We are well aware, for example, that certain batteries, after being kept for a certain time on short circuit, polarize, and that this polarization sets up an opposing electromotive force which weakens the legitimate current.

So also we are familiar with the recent developments in this class of electrical work, whereby this polarization is utilized in the so-called accumulators, or storage batteries. We know that where a current from a battery or dynamo is employed to energize an electro motor, the revolution of the motor armature in its own field of force must necessarily generate a counter current, which equally of necessity, diminishes the strength of the working current; and calling the initial electromotive force E, the counter electromotive force F, the resistance of the entire circuit R, and the current flowing in the circuit C, we may express the value of the said current thus: $C = \frac{E-F}{R}$.

As stated, the magneto transmitter suffers from this cause, for its current, small at first, has no surplus strength to spare. Two magneto telephones in a circuit, one acting as transmitter, and the other as receiver, are virtually in the relation of dynamo and motor, and the vibrations of the receiving diaphragm, when actuated by those of the transmitting diaphragm, set up a counter current which weakens the original current in the manner indicated by the equation.

Of course, this action takes place also when a battery transmitter is used; but in that case the original current is stronger, and is better able to hold its own against the parasitic current.

The fact was accordingly recognized at an early date in telephonic history that it was very desirable to provide a transmitter which, retaining simplicity of character, should be able to control currents capable of operating upon the receiver, and enabling it to reproduce speech considerably louder than the magneto instrument as ordinarily constructed is capable of doing. Graham Bell had already, in his patent of 1876, pointed out that the magneto mode was not the only one of developing the necessary character of the electric currents; and that this could be accomplished likewise by varying the external resistance of the circuit, as also in other ways; and the telephonic transmitter, now commonly used, *is, so far as its initial operation is concerned*, based upon the variation of external resistance.

In this form of transmitter the voice is merely required to act as the controlling force of an already generated current, which is due to a voltaic battery; whereas, in the magneto telephone, the transmitter must itself accomplish the work of generating the currents.

Battery transmitters all aim at the utilization of the vibrations of a diaphragm to effect a variation in the resistance of a circuit; and this implies the use of some special substance or special arrangement of parts to constitute a variable resistance, arranged in the circuit in such a way as to be under the control of, and capable of, responding to the movements of the vibratory plate. Such an instrument is the well known Edison transmitter, which operates by the varying intimacy of the several particles of a button of soft lampblack carbon, this button being introduced into the circuit with a battery and a receiving telephone.

Such an instrument also is the better known Blake transmitter, which operates by increasing or decreasing the pressure between the two terminals of a battery circuit (one of these usually being carbon and the other platinum) at their point of contact; an initial degree of pressure being applied by springs. Transmitters of the Hunnings type, in which a mass of granulated carbon or like material is enclosed in a loose and free state between two conducting discs, which form the two electrodes of the battery circuit, belong also to this genus; and are, to use the phraseology of the elder Mr. Weller, "pop'larly supposed" to be the key to long-distance telephony.

The diagram, figure 6, may serve to illustrate a simple telephonic circuit, A, B, in which are included a variable resistance transmitter T, a magneto receiver R, and a battery *b*, the current from which is varied in strength by the operation of the transmitter.

The use of the magneto telephone as a generator and transmitter of electric currents controlled as to character in the generator itself, and in the very act of development, may be compared to a steam engine in which the amount of steam supplied is regulated solely by varying the

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amount of steam produced, or by regulating the heat of the furnace; while the use of a constant battery, the current of which is varied continuously by a variable resistance transmitter, may be compared to a steam engine

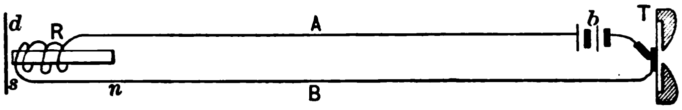

FIGURE 6.

provided at all times with a good head of steam, the amount supplied to the cylinder being at the same time controlled and regulated by a throttle valve, which admits more or less, as may be required.

I have not described in detail the operation of any of the forms of battery transmitter, as it is familiar to most of the readers of the ELECTRICIAN AND ELECTRICAL ENGINEER, and as a review of their general principles is sufficient for the purposes of this article.

It becomes now necessary to call attention to a feature of the battery telephone circuit, which I think may be studied with profit. From what has been said, it is evident that the varying currents generated and employed when a magneto transmitter is used (whether it be provided with a permanent magnet as in plan A, or with a temporary magnet excited by a special coil and local battery as in plan C), are alternately of positive and negative direction; and that in the second, or original plan, B, wherein the magnetizing battery is actually included in the line circuit, the operating currents are generated in alternate or negative impulses, but since they act merely to reinforce or depreciate the force of the battery current, the changes which reach and affect the receiver are not alternating in direction, but simply changes in strength. The arrangement we are now contemplating is not precisely identical with any of these, and at no time is the direction of the currents alternated. We have, as in plan B, a constant battery in circuit; but instead of varying the strength of its current by superimposing upon it additional currents of alternately opposite sign, which gradually strengthen and weaken the original current, we vary the work which the battery has to do, by causing the vibrations of the diaphragm to alternately raise and lower the resistance of the circuit.

The ultimate result is, of course, the same; that is, the electrical excitement of the circuit, including the receiver coil, is raised when the resistance is lowered, and lowered when the resistance is raised, and the receiver diaphragm sustains a corresponding variation of attraction.

This, then, is the first case which has come before us in which currents of alternating direction perform no part. The changes are in strength only, and the undulations may be represented by figure 7.

The line A B is once more the zero of current, and the curve x y represents the current, which, though varying regularly and gradually in strength or intensity, as indicated

FIGURE 7.

by the sinuosities of the curve, is unaltered as to direction, this characteristic being indicated by the position of the curve, which does not cross the line. We may call this plan D. If this plan be strictly adhered to, without the addition of any supplementary device, it is not easy to regard it as being, even in a slight degree, superior to the several magneto plans; for though the reproduced conversation is, it is true, much louder upon a very short circuit, the results are, with most forms of instrument, very inferior when the circuit is of any considerable length or resistance.

This seems to have always been recognized, inasmuch as only in one or two very rare instances has this plan, in its purity, been adopted in commercial practice. There are three grave obstacles to the exact practical operation of the above mode. These are the following:

First: Such an arrangement involves the use of a battery proportionate in some degree to the length of line operated—a long line requiring a battery of many cells, while even the shortest lines would require more than one cell, and the system would thus be an inordinately expensive one.

In the second place, if we connect a battery of proper strength together with the resistance-varying transmitter in the main circuit leading to the receiver, the current produced by the battery has an electromotive force directly proportional to the battery; and this can be but low, since it is obviously impracticable on the score of economy to use very large batteries.

The third and chief obstacle is the fact that the effectiveness of the received conversation is due, not to the strength of the line current when at rest, but to the amount of variation which can be produced by the transmitter in that current. Now, the very greatest variation in the resistance of the transmitter that we can create by speaking against the diaphragm, it is quite clear, is, at the best, but an inconsiderable factor in a long line circuit, although in a short circuit it would be proportionately great. For example—Suppose the original resistance of the transmitter contact is one unit, that the maximum resistance during the operation of the transmitter is eleven units, and that it is included in a circuit having a *total* resistance of 200 units, it is evident that the variation of circuit resistance is only from 200 to 210. But if the same transmitter be connected in a circuit having a total resistance say of 30 ohms, the variation will bear a much higher ratio to the resistance of the circuit, being from 30 to 40 ohms—in the former case the variation is equal to one-twentieth, and in the latter to one-third of the normal circuit resistance.

These considerations it was which led to the adoption of the induction coil, and to its combination with the battery transmitter, and once adopted, its operation proved so satisfactory that it was permanently incorporated as a part of the invention, and so universal is its use, that few, I apprehend, who use a battery transmitter have ever thought that it could, even upon the shortest circuits, be employed without the induction coil.

It is true that certain transmitters of the type using a current-varying medium of granulated carbon, can readily be operated in direct circuit with the battery and receiver; and I have so used the Hunnings transmitter; but it is not economical in the use of battery, and to get the best results, it becomes necessary to provide approximately one cell of Daniell battery per mile of line.

It is the normally high resistance, and the extent of variation that can be made therein, that enables the granulated carbon transmitter to perform this work.

The adoption of the induction coil enables us to produce a working current of much greater force—a much greater power of traveling fast and far, and of overcoming faults and high resistance, than is possessed by the original battery current that induces it, and thus more efficient work is done, and we can converse over greater distances. We can also restrict ourselves in most cases to one cell of battery, and with very long lines need not use more than five or six cells.

Moreover, by including the transmitter and battery of the primary circuit of an induction coil, as is done usually, we obtain the required range of variation in resistance; for, supposing the range of the transmitter variation when in operation to be from one to ten units, and that the entire resistance of the local circuit, including primary coil, transmitter and battery, is normally ten units, the extent of the change is actually from 10 to 100 per cent. of the entire normal resistance. Therefore, by

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placing the variable transmitter resistance in the short circuit of a primary coil of an inductorium, and by including the fine wire or secondary coil of the same inductorium in the line or main circuit, as in figure 8, we are enabled to utilize the comparatively small change in the resistance of the local circuit to effect a proportionately great difference in the current strength, and thereby to develop

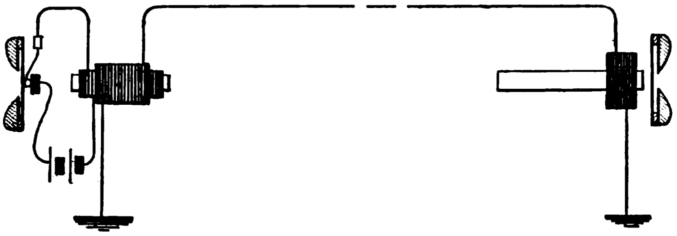

FIGURE 8.

in the secondary coil, and hence in the line circuit of which it forms a part, induced currents having as wide a range of variation in the line circuit which they transverse, as the battery currents which induce them, have in the primary coil and circuit; and they consequently act with equal vigor upon the diaphragms of all the receiving telephones in the main circuits, irrespective of distance.

The first United States patent showing this use of the inductorium, is that of Berliner, No. 199,141, which was issued as early as January 15, 1878, and for which application was made as early as October 16, 1877. It seems, however, to have been first commercially applied by Mr. Edison, and is hinted at in the provisional specification of his British patent as early as July 30, 1877. It is also shown in connection with a short circuiting transmitter in his U. S. Patent No. 203,013, to which I shall refer again.

(*To be continued.*)

PRACTICAL DYNAMO BUILDING FOR AMATEURS.[1]

OF the mighty army of scientific amateurs there are thousands who would like to construct a practical dynamo, and thousands who have already made a small one, and are desirous of extending their practice with a larger machine. There are many instances where the amateur electrician has every facility, every convenience and tools at hand wherewith to construct a dynamo and its necessary adjuncts, that will afford him 50 incandescence, or one 20,000-c.p. arc-lamp at will, with the same winding. Take, for example, an engineer in charge of the machinery in a large works; he has his forge, turnery, vice-bench, and pattern shop, and given a rudimentary knowledge of the principles of electric lighting, and the necessary instructions, there is no reason why he should not at once gratify his own inclinations, and give his employer the benefit of the electric light. In the present series of articles the use of engineer's tools, and also a fair groundwork in the theory of electricity, including Ohm's law, is premised by the author.

In the little dynamo here described and illustrated, the field-magnets consist of simple soft cast iron, not from preference, but because such material is far easier for the amateur to fit up, than the more expensive and troublesome forgings, which can rarely be obtained to correspond unless made from a die.

On the other hand, the armature consists of a series of links, each forming the segment of a circle made of best charcoal sheet-iron, and insulated in a manner to be described afterwards, so that the "eddy" or Foucault currents are retarded, and their perceptible effect diminished as much as possible.

Such a dynamo machine requires in its construction no particular skill beyond that which every true mechanic must have attained before he can be worthy of the name: care and accuracy, combined with judgment, will insure success. The lathe, if a good 8in. surfacing screw-cutting, with gap bed to take a radius of 1ft. 6in., will suffice to do all the work that requires a power tool. Here the amateur dynamo manufacturer may drill the field magnet castings, turn the spindle, armature ends, and commutator, and bore the poles if it be necessary. With the same tool he may wind the field bobbins, and bind the armature; in short every operation may easily be performed upon such a lathe, and good work be turned out with it as the only tool; yet where a separate drilling and planing machine is in use, the advantages in favor of the amateur are greater.

No father can be prouder of his first-born, than that amateur whose brow has been touched with the divine fire of genius is of his first practical dynamo. How he watches the thin phosphorescent line that intervenes between the brush and the commutator, and is the visible sign of an actual current that in flowing round the magnet coils shall so augment itself as to develop light, heat, or power in an exterior circuit.

Using the same castings and armature, but differently wound, the same dynamo may be made to give different values of currents and electromotive force, and it is the writer's intention to give practical instructions upon such winding for the convenience of the amateur, so as to meet his requirements within the range of the machine.

FIELD MAGNETS.

The field magnets, as illustrated in figure 1, are of cast iron, in two pieces, A and B, which are bolted together by the bolts *a a*, which should be turned to fit the holes fairly well, so that there should be no rock or tendency to shifting when the machine is fitted up. The cores of the magnets *b* are oval in section, in order that the wire should not be strained in winding, as it would over a flat core with rounded ends. The patterns should be carefully constructed so as to minimize the tooling and fitting, and when this is done it should not be necessary to bore out the pole pieces *c*. This bore is not circular, but, as is plainly shown in the drawing, chamfered off toward the edges of the pole pieces, the armature being represented by the dotted line. The feet *d* of the dynamo may have the holes cast in, and for that purpose prints must be attached to the pattern for $\frac{3}{4}$in. clearing holes. The projections which are cast on the magnets, form bobbin ends, for the proper winding and protection of the wire.

The holes for the bolts *a* may also be cast in, and subsequently cleaned out by a bit; but if the tools at the command of the amateur should allow of it, it is preferable to drill these holes $\frac{3}{4}$in. and fit the bolts *a* to them. The holes marked *f* upon the plan, figure 1, are $\frac{3}{8}$in. tapping, and serve for attaching the terminal board, to be described afterwards. The $\frac{1}{2}$in. tapping holes *g*, shown in the side elevation in figure 1, must be marked off after the bearing ends are fitted. The surface of the joint *h h'* between the two halves of the field-magnets should be planed, or chipped and filed, so that the polar bore is parallel, and of exactly the right diameter when the whole is fitted together; therefore, to enable this to be done, the pattern should have a piece of millboard, or thin wood glued upon it, of a thickness that will enable a good well-fitting surface to be obtained by planing, or chipping and filing. If a planing machine is available, a cut may be taken over the feet *d*, and so provide a true base for bolting the dynamo upon its foundation when finished.

Each half of the magnets must now be centred, so that the cores *b* may run tolerably true in the lathe, these centres being drilled and counter-sunk, so as to allow of the strain of winding without accidents, and the two halves then bolted together, may be placed aside, ready for the bearing ends to be fitted.

1. *English Mechanic.*

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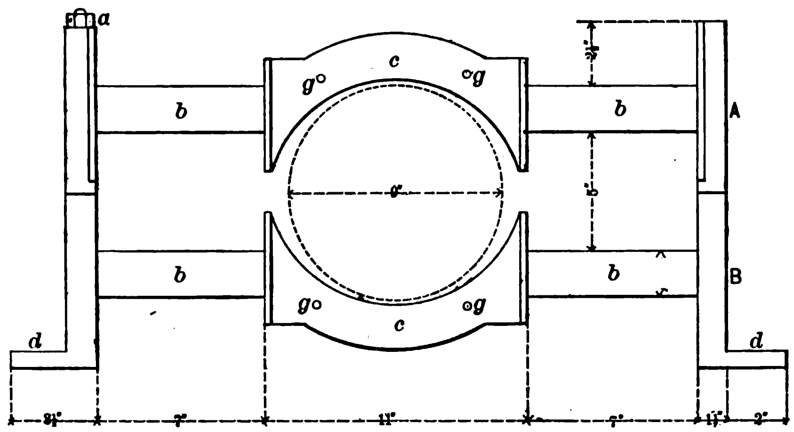
All the sizes are carefully marked upon the drawings throughout, so that these do not require recapitulation here.

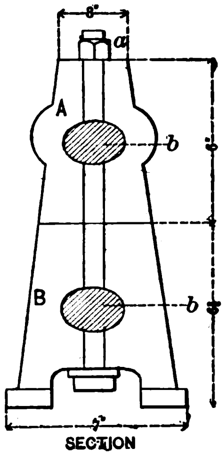
The bearing ends, figure 2, are to be cast in gun-metal and, as will be seen, are designed so as to allow a long surface bearing, and also afford a support for the pole pieces, rendering the whole mass perfectly rigid when bolted together.

A fillet, at *h*, is cast upon the flange, of a diameter to allow of turning up to fit the polar bore tightly, and the whole is as light as the weight and strain that is imposed upon it will permit. One of these bearing ends, D, is elongated as shown, to allow of the commutator and brush-holder. This one is fixed to the face-plate by the flange, and bored out to 1in., smooth and parallel. Then, driving it upon a mandrel, the boss may be skinned and faced, the inner portion *k* turned to fit the bore of the brush-holder, then the flange may be faced, and the fillet *h* turned to fit the poles. The holes *j* are drilled, ½in. clearing, and one ⅜in. tapping in the boss, shown dotted at *i*, to receive the lubricator. The bearing end E is similarly bored out 1¼in., and turned, faced, and drilled in the same manner, and then both ends may be put in position, and the holes *g* in the pole pieces drilled and tapped, and the ½in. set screws fitted, ready for permanent fitting up. If the pole pieces have been bored out, it is fair to suppose that the end pieces have been faced also, in which case the bearing ends will not require any adjusting, but their respective bores should be opposite, and parallel to a common centre line, and not cause the spindle to bind.

However, if, on the contrary, the poles have not been bored, the faces will require a little fitting before the spindle will run freely, and in this case it will be better to wait until the latter is turned before adjusting the bearing ends.

The next portion of the dynamo that claims attention is the two gun-metal wheel ends for supporting the armature ring. These are shown in front and side elevation by figure 3, and the pattern is sufficiently simple in construction as to require no explanation beyond the drawing. These wheel-ends are bored out 1¼in., and turned bright all over, with a parallel feather-way cut in the one nearest the commutator, and a keyway in the opposite one. It is extremely important that these keyways should be coincident, that designed for the feather being ¼in. square, and the other ⅜in. by 5-16th inch, as shown. A centre being fixed in the bore of each wheel-end, a circle must be marked with the compasses 6¾in. in diameter, and this carefully and accurately divided into six parts, which will form the centres for six ¼in. clearing holes.





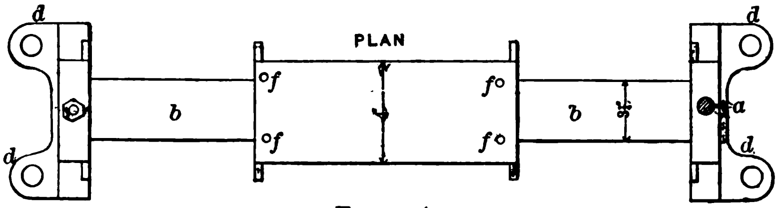


FIGURE 1.

The marking and drilling of these holes must be performed with the utmost care, or the subsequent building-up of the armature will be distorted, and it will never run true, which is a fatal error in dynamo manufacture, since the shifting of the centres of force in an unbalanced armature frequently leads to its total destruction.

SPINDLE.

A good piece of mild steel of even grain must now be chosen for the armature spindle, figure 4*a*, which must be turned to fit the bearing ends D at *k* and *k′* respectively, the wheel-ends also being a good fit at *l* and *l′*. The screw-thread may be of any convenient fine pitch, say, 12 to the inch, and the steel hexagon nuts, *n n*, faced up perfectly true, and slightly hollow on the inner face.

The keyway (flat) at *l*, and the sunk feather at *l′* may now be finished, and the wheel-ends tried thereon, so that the six small holes around the latter may be exactly opposite when the ends are firmly keyed up to their proper distance apart, viz., 5″.

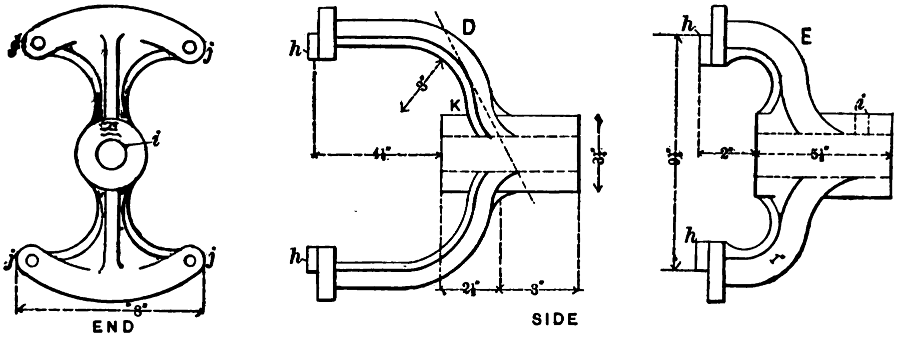


FIGURE 2.

ARMATURE CORE.

The next operation will be the building up, insulating, and winding of the armature. Two rings, of 3-16in. sheet iron, figure 4, are cut out, turned and faced perfectly true on both sides, the diameters, outer and inner respectively, being turned to the *exact* size specified upon the drawing. These rings are marked off for six ¼in. holes, to coincide perfectly with the ¼in. holes that have already been drilled in the wheel ends. The slightest deviation from perfect accuracy in drilling and marking off any of these holes will certainly insure failure in the armature.

The six holes in each ring should then be plugged with plugs of vulcanized fibre or boxwood, and again marked off, and the plugs drilled ¼in. clearing.

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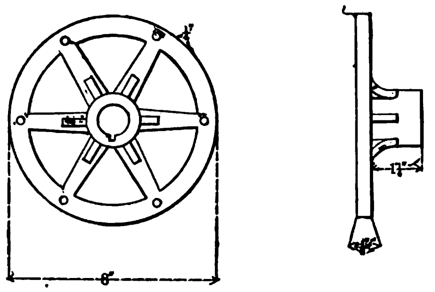
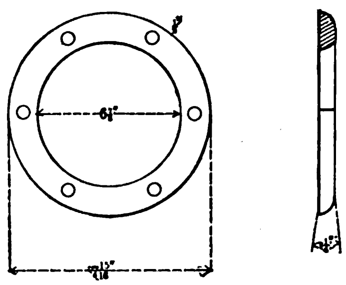
It will be noticed in figure 4, that one edge of the rings is well rounded, so that a sharp edge is not presented to the wire, which would tend to cut and destroy insulation. Six pieces of drawn iron wire, No. 4 B. W. G., should now be cut off, 10in. long, and screwed at each end to a distance of 3½in., leaving 3½in plain in the centre. Small gun-metal hexagon nuts should be fitted to each end of these studs, and it will be advisable at this stage to make a plate spanner to fit them. Twelve small gun-metal ferrules are

FIGURE 3.



GUN-METAL WHEEL ENDS (2)

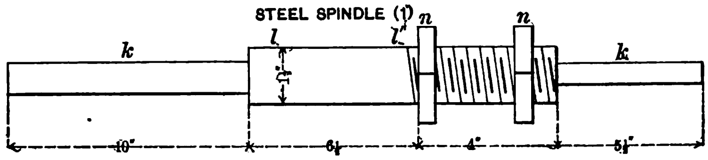
FIGURE 4.



WROUGHT IRON RING (2)

GUN-METAL FERRULE (12)

FIGURE 5.

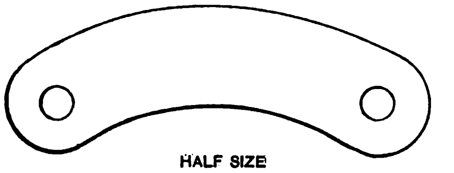


STEEL SPINDLE (1)

FIGURE 4*a*.

then prepared, figure 5, drilled out to ¼in. clearing, and turned and faced as shown.

It is necessary now to prepare the charcoal iron segments which are to form the armature core. Figure 6 represents one of these segments, half-size, and the gauge of the sheet iron out of which they are stamped or cut is No. 20. In the construction of the present armature about 240



HALF SIZE

FIGURE 6.

segments will be required; therefore, it will hardly be worth while for the amateur to make his own dies when the punchings are to be had very cheaply—about 4s. per gross.

The next step towards the building up of the armature

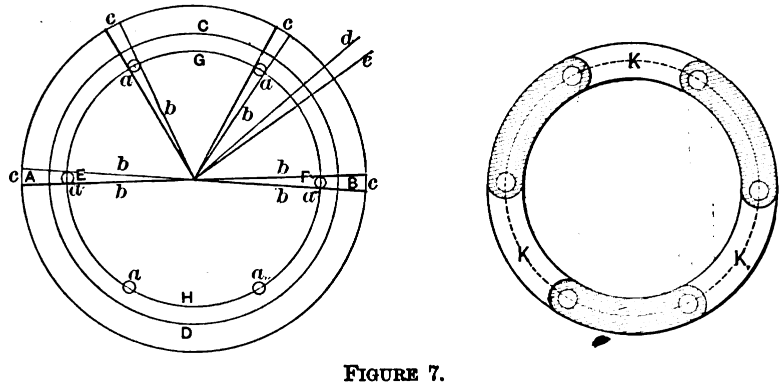


FIGURE 7.

is to cut out 60 discs of paper, exactly to the wrought-iron rings, as shown in figure 4. The holes may be then punched by an ordinary belt-mender's punch upon a block of hard wood. The paper discs must be painted on both sides with shellac varnish (spirit), and hung up to dry. The sheet-iron segments should also receive a coat of Brunswick black by warming and dipping and then laid aside to dry.

The six studs must now be taped with two layers of tape, well painted with shellac, and the ends fastened with Prout's elastic glue. This taping, however, is confined to the 3½in. of the plain portion of the studs. One of the wrought-iron rings, with its insulating bushes, is now threaded upon the six studs, and the ferrules before mentioned next, and then the nuts, leaving the other end of the studs free for building up.

A piece of board should have six holes bored in it to coincide with the studs, and their lower ends, projecting beyond the nuts, be placed therein, so as to keep the free ends in place and tolerably rigid. After painting the inner surface of the ring with the aforesaid shellac varnish (which should be kept in hand, being constantly in requisition), two of the paper discs may be slipped over the studs, and pressed upon the wet shellac. Three segments must be threaded upon the studs, as shown by the lighter shaded portion K in figure 7, missing a space between each, then the next three, indicated by the dark shade upon the alternate studs. This constitutes one layer, and the order of building should not on any account be deviated from, lest the armature should be irregular in form when finished. Each four layers should receive a coat of shellac and two discs of paper before again commencing to build.

When 220 segments have been thus built up, two discs of paper must precede the wrought-iron ring, the rounded edges of which should be placed outwards. The remaining six ferrules may now be threaded upon the studs, and the whole screwed up by the plate-spanner, a few turns at a time to each nut, until the whole mass is rigid, and 4½in. in length.

It will be wise at this stage to allow the core to dry, either in front of an open fire, or upon a steam boiler—the latter method being preferable where practicable, because the heat is uniform.

The insulation of the sections of the core can now be tested by a small battery and detector galvanometer; but if the instructions relating to the building and insulating are carefully carried out, the result cannot fail to be satisfactory.

The operation of tapeing is the next that has to be performed, and this is done by wrapping the tape tightly in a longitudinal direction, over and under alternately, until the whole core is covered, except the spaces left by the projecting ferrules. Shorter lengths of tape are attached by shellac across these gaps, and the ferrules themselves taped around. Two layers of tape will be found sufficient; then the whole should be saturated with the varnish and laid aside to dry.

(*To be continued.*)

ELECTRICAL LIGHTING BY MEANS OF LOW RESISTANCE GLOW LAMPS.[1]

BY ALEXANDER BERNSTEIN, FOREIGN MEMBER.

IT is not uncommon in the history of technical science to find that constructions which have at one time been abandoned on account of apparently

1. Read before the Society of Telegraph-Engineers and Electricians, London, March 25, 1886.

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insurmountable difficulties have, after a certain lapse of time, been readopted. The high-speed engine, the high-pressure boiler, the multiple telegraph system, were known and made long before they were generally applied, because their practical application was impossible until a certain amount of experience had been obtained by means of the low-speed steam engine, the low-pressure boiler, and the single telegraph system.

In a very similar manner the low-resistance glow lamp was known and made more than thirty years ago, but has hitherto been considered impracticable. In the meantime the glow lamp of high resistance has made its way, and has met with considerable success. Now to-night I desire to revive the older type of lamps in a new form produced by means of our present experience, and to show at the same time the way in which these lamps may be made to answer the purpose of electric lighting.

As we have been so often told that the lamp of low-resistance is neither practical nor economical, I must suppose that most electricians are somewhat prejudiced against it. But prejudices are detrimental to the development of truth, and I must therefore request you to take as impartial a view as possible of the case which I shall lay before you to-night.

High or low-resistance of glow lamps is not merely a question of construction of the lamp itself; it is a question of principle which determines the whole system of lighting. The requirements of the dynamo, the sizes of the conductor, and the whole system of arranging the circuit, are entirely dependent upon the lamp which we select. It is therefore not sufficient to compare different types of lamps in regard to their qualities as lamps; it is quite as essential to consider how the use of these lamps answers the practical purpose of electric lighting. I shall therefore divide my paper into two parts—the first, dealing with the lamp itself, the second, with the manner of its application.

In speaking of glow lamps, and considering their merits, I shall only take such lamps into consideration in which carbon is brought to a state of incandescence, and emits light by reason of its elevated temperature. Although other substances may be used, experience has shown so far that none of them offer the advantages which are secured by the use of carbon, viz., the possibility of applying a very high degree of temperature. This is very essential, because the highest temperature implies the greatest efficiency; and efficiency, together with durability, are the two qualities which principally determine the merit of an incandescent lamp.

Before proceeding any further, allow me briefly to enumerate the principal parts which constitute an incandescent lamp. These are only four—the glass bulb, the conducting wires (which always consist of platinum as far as they are surrounded by glass), the light-giving carbon, and the connection between the carbon and the wires (generally called the mounts). The simple construction of such a lamp does certainly not indicate that its manufacture is beset with so many difficulties. In order to settle our terminology, I shall further mention that the reciprocal of the number of watts required for every candle-power of light emitted will be called the "strain;" so that the strain is small if the number of watts per candle is comparatively large.

The light which is emitted by incandescent carbon depends only upon its temperature and the amount of its radiating surface; but the energy which is required to maintain this light would be determined—irrespective of the losses which may occur in the lamp, and under the supposition that the state of vacuum and the exterior temperature remain unaltered—by those same two magnitudes alone, if the radiating power of all carbon were alike. It seems to me that this last is not the case. From certain analogies, well known in physical science, we may conclude that a black, sooty carbon will radiate more heat than a carbon of a dense grayish surface raised to the same temperature, and consequently the former will require a larger supply of electric energy to maintain it at the same temperature than the latter. This fact seems entirely borne out by observations made on glow lamps.

Let us now consider the peculiarities of a glow lamp of high-resistance, say of 100 volts and 0.6 ampère. I select this lamp because it seems that this is approximately the highest resistance lamp which can be practically applied at the present time. At least, I can see no reason why the complicated expedient of a multiple-wire system should be used, if electric lamps can be made reliable when working at a much higher difference of potential and with a corresponding smaller current. As the lamp is only to take 0.6 ampère, the filament must be exceedingly fine in order to become sufficiently heated by this current, and moreover, the filament must be of sufficient length to obtain the necessary amount of light-giving surface. As soon as the current is passed through the filament, the latter is raised to a certain state of incandescence; and we shall therefore have to deal first of all with the effect which heat alone seems to have upon the carbon.

Heat has a general tendency to expand all substances; and as it was interesting to know how far carbon is subject to the same law, I have investigated this question by means of a lamp of the following construction:—Two straight filaments are connected by means of a cross piece of platinum in the form of a **T**, which acts on a lever so arranged as to indicate ten times the elongation of the filaments when these are heated. The annexed sketch in which A A are the filaments, and B the indicating lever,

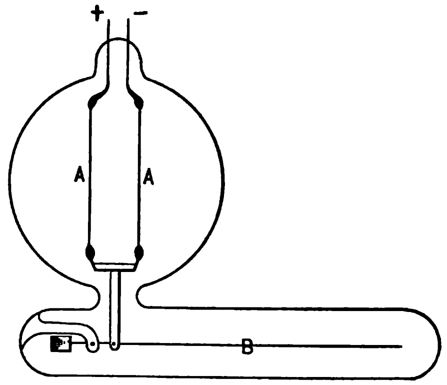

FIGURE 1.

shows the arrangement which was adopted. The experiment indicated that when the carbon was exposed to a strain of 3 watts per candle, the elongation of the filaments amounted to one 120th part of their length. It was further noticed that the rate of expansion was not constant, but increased with the temperature, although at the highest temperatures obtained the coefficient of expansion seemed to decrease again.

The fact that the carbon expands and contracts with every change of temperature explains why lamps with slender filaments are destroyed more quickly when subjected to varying currents than when they are fed by a constant and uniform current, such as that supplied from batteries.

When we look at a heated filament, we notice sometimes that one small spot is brighter than the rest of the filament. This is an indication of a flaw which will sooner or later produce the disintegration of the carbon at this particular spot. These flaws are, for the most part, so minute that they cannot be perceived in the filament when cold, and only gradually show themselves when the lamp is being used. This is one of the causes which produces premature destruction of the lamp. The finer the filament the greater the danger of a flaw.

It has lately been supposed by some writers on the subject that the life of a glow lamp is in direct proportion

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to the diameter of the filament. Such suppositions, which are mostly made for the sake of obtaining mathematical formulæ, are far too sweeping; and all we are entitled to say is that, *cæteris paribus*, the lamp with a thick filament promises greater durability than the one with a thin filament.

We have before observed that heat produces expansion of the carbon, and from this we may infer that if the heat is sufficiently high, evaporation or disintegration of the carbon would be the result. Such is the case if the carbon is of a soft quality and raised to a very high degree of temperature; but we are fortunately in a position to produce a carbon of such dense and hard structure that there seems to be no perceptible disintegration at the temperature usually employed in incandescent lamps. If we, nevertheless, observe in high-resistance lamps—even if worked at a strain of no more than 4 to 5 watts per candle, and a corresponding low temperature—that the carbon filaments are disintegrated, that the resistance of the lamps consequently increases, and that the glass bulbs begin to blacken, we are led to suppose that other forces must be at work which produce the destruction of the lamp. These forces are of an electrical nature, and their existence is easily explained if we consider that an electric glow lamp is at the same time a vacuum tube.

In the high-resistance lamp we have considered before, there is a difference of potential of 100 volts between the two terminals of this vacuum tube. The fact very soon makes itself apparent in the lamp. If the temperature is sufficiently high, the negative side of the carbon assumes a dark, sooty appearance, and a deposit of black loose carbon is formed on the positive platinum and mount. This action of throwing off particles of carbon from the negative side towards the positive has been the subject of a very interesting paper communicated to the Royal Society by Mr. Preece. The peculiar behavior of high-resistance filaments is evidently the effect of a combined action of heat and electricity. The heat lessens the attraction of the particles for each other, and the electric forces produce motion. The result is the gradual deterioration and ultimate destruction of the carbon.

It has often been noticed that a blue flame makes its appearance upon the positive platinum when the carbon is raised to a high state of incandescence. As no explanation of the production of this blue flame has as yet been given, I beg leave to insert here a few words respecting the most probable cause of it.

All platinum, when cold, occludes a large quantity of oxygen, which is given off again when the platinum becomes heated. The black, sooty deposit of carbon on the positive platinum is just in a condition to combine readily with the oxygen, and both together form the blue flame. While the lamp is on the vacuum pump this flame may often be seen to travel up and down the platinum wire, always appearing where occluded oxygen is set free. If the pumping continues without the current being increased, the quantity of free oxygen is soon consumed, and the blue flame disappears, but reappears again if the temperature of the platinum is increased by increasing the current. Just in the same manner finished lamps will, under all normal conditions, show no blue flame, but will do so if an excessive current is passed through the lamp. In this case a blue flame is sometimes seen on the negative platinum as well. This occurs because particles of carbon find their way to the negative platinum and are oxidized there in the same manner. As the spectrum of the blue flame has been observed by Messrs. Liveing and Dewar to be that of carbonic oxide, it seems so much the more probable that the explanation here given is correct.

We have now to notice another effect of the vacuum tube. When lamps are made for very high difference of potential and corresponding small current, there seems to be a very strong tendency of the current to leap across from one terminal to another, thereby short-circuiting the lamp, destroying the filament, and fusing the platinum wires. This tendency is very strong when the current is turned on suddenly, as the carbon, being cold, then offers the highest resistance to the passage of the current.

One of the conditions which it is desirable to observe in respect to a practicable lamp is that a certain excess of current such as is liable to occur in installations must not be able to destroy the lamp; and in this respect it is certain that the lamp with a thick filament is far superior to the lamp with a thin filament.

Turning to another point of practical importance, we notice that lamps with fine filaments are exceedingly subject to flickering as soon as the strength of the current varies but slightly. Variations of this kind may have their cause in irregular motive power, in slipping of a belt, or in a dynamo which is not perfectly balanced either mechanically or electrically. Such flickering will be noticed in a great many installations with small-current lamps, and is exceedingly disagreeable to the eye. Now, with a large hollow carbon used in the lamp which I shall presently describe, the interior is always at a higher temperature than the exterior, and serves as a reservoir of heat which allows for certain variations in the current, without any effect on the eyes as regards the light.

How are we, then to obviate these difficulties appearing in the lamp? If the thin filament does not promise much durability, and is disadvantageous in other points mentioned—if the high difference of potential proves to be a factor in the destruction of the lamp—we must employ thick filaments and a small difference of potential; or, in other words, we must produce a low-resistance lamp.

I think I have sufficiently shown you the right of existence of a low-resistance glow lamp, and I shall now proceed by describing the lamp which is before you, the form of which seems to be one of the best of all the varieties of low-resistance lamps which I have made since 1882.

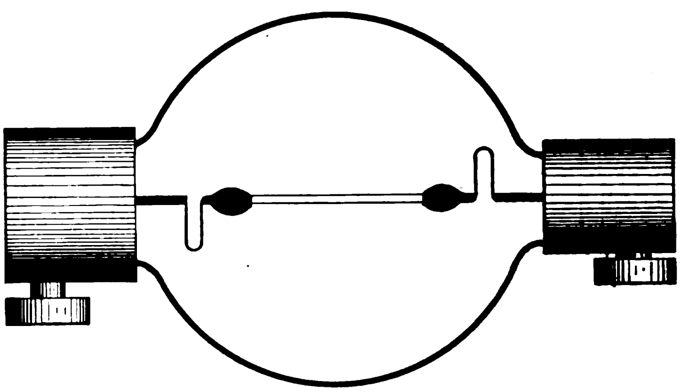

FIGURE 2.

The lamp which is shown in the above figure consists of a glass bulb of oval shape, into the opposite ends of which the platinum wires are sealed. In this manner the glass is placed symmetrically round each wire, and is therefore less liable to crack when heated. The carbon has the form of a straight tube mounted upon short pieces of stout platinum, which are joined to the platinum wires passing through the glass by means of flat thin copper strips, bent upon themselves so as to form springs at right angles to the direction of the carbon. In this way all parts of the lamp can expand and contract without subjecting the carbon to any injurious strain. A cap of insulating material at each end of the glass bulb provides for proper connection with the conducting wires, which may be made to support the lamp; and this connection is made in such a manner as to prevent accidental contact of the manipulator with any part carrying a current.

The success of these lamps depends on the satisfactory construction of every one of its details in an almost equal degree. The quality of the carbon, the way in which the

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same is mounted, the manner of surrounding the platinum wires with the proper kind of glass, the avoidance of any mechanical strain, and the proper proportion of every part of the lamp, are all the results of tedious experiments, which were necessary in order to produce a satisfactory lamp. The electrical dimensions of the lamp are as follows: It requires a current of 9.75 ampères, thereby showing a difference of potential of 7 volts, and a hot resistance of about 0.7 ohm.

When speaking of the high-resistance lamp, I have mentioned that there seems to be a limit to the difference of potential which we can apply in each bulb. As regards the low-resistance lamp, there is a limit to the strength of the current of which we can avail ourselves. The difficulty rests with the wires, which have to be sealed air-tight into the glass, as it is far easier to seal in thin than thick wires carrying a large current.

Before concluding this first part of my paper, I shall have to mention one of the drawbacks of the low-resistance lamps, to which Professor Forbes has called attention in his excellent lectures on the distribution of electricity, viz., the loss of heat in the conductors inside the lamp. I quite agree with Professor Forbes that in older types of lamps the loss was very considerable, and a serious question; but in the lamps which I made some years ago this loss amounted to only one-tenth part of the energy consumed. I am happy to inform you that in the lamp before you this loss has been reduced to one-twentieth part of the energy required in the lamp.

I shall now turn to the second part of my paper, and I shall consider it best to attack at once the most difficult problem which can present itself, viz., the supply of a large number of lamps from one central station, with the condition that all the lamps can be used entirely independent of each other, and with the further condition that the expenditure of mechanical energy shall always be proportioned, or, at all events, approximately proportioned, to the number of lights in use. Our imaginary plant is to be arranged for 6,000 lamps, requiring 9.75 ampères, and upon the average six volts each. Let us first look into the central station and consider its requirements. We shall settle upon the use of a dynamo which, with a current of 10 ampères, is capable of producing an E.M.F. of 2,000 volts—a kind of dynamo which was first applied by Mr. Brush, and which is already extensively used for arc lighting, or for a combination of arc lights with groups of glow lamps, several of the latter being always arranged in parallel. But the lamps of which I spoke at greater length in the first part of my paper are made for the passage of the whole current, and will therefore be arranged in series, one being placed in the line after the other. In this case there will be more than 300 lamps on each line; let us say 300. We shall therefore require 20 such dynamos, and one or two spare machines in case of repairs.

These 20 dynamos may be driven from shafting, or each by a separate steam engine. There are 20 separate lines proceeding from the central station, and as the main condition of our system is that the current on every line must always be kept constant, we must provide for the regulation of each dynamo in such a manner that the E.M.F. always corresponds to the number of lamps which are in use. This regulation can be effected by automatic devices, or may be done by hand in adjusting the magnetic field or the speed of the dynamo. An ampère-meter which is placed in every circuit will indicate whether this condition is fulfilled, and a voltmeter connected with the terminals of each circuit will inform us how many lamps are used on each line at any time. A registering voltmeter placed in the same manner would be another useful addition. The central station, furthermore, contains a switch-board, which allows any one of the circuits to be connected with any one of the dynamos. If we presume that the station is to supply current day and night, it would certainly be absurd to run all the dynamos constantly at those times, when only a small number of lights are required. At daytime, then, I should propose to loop several circuits together, and if the total number of lamps is sufficiently low, all the 20 circuits might be looped in a single one, so that only one dynamo need be kept running. By means of an auxiliary line of lamps in the central station, dynamos and circuit may be switched in and out without any sudden change in the conditions of either. The system of working would then be that in the afternoon one dynamo after the other is switched into its respective circuit, the requirements of which can always be ascertained on the voltmeter of this circuit. If the consumption of light decreases, the dynamos are gradually switched out again. By the addition of an arrangement for observing and measuring the state of insulation of every line, the outfit of the central station might be considered complete. I have not mentioned any apparatus in connection with the central station which could not be easily constructed with the means at our disposal at the present time.

We now leave the central station, and turn our attention to the conductors. These are 20 pairs of copper wires of small size, say No. 6, well insulated. Experience has shown, so far, that there seems to be no great difficulty in insulating a wire if the tension of the current is not more than 2,000 volts. If we suppose that the central station is in Pimlico, on the banks of the Thames, a few wires may be laid in the direction of Victoria Station, a few more may reach the Houses of Parliament, some may be laid in the direction of South Kensington Museum, and some others may be used for lighting private houses—in each of which I shall suppose that, upon an average, 20 lights are used at the same time. In this case 15 houses are passed by the same conductor, which supplies current for 300 lamps. All these lights can be turned on or off at will, quite independent of each other, because we have provided in the central station that each dynamo is regulated in such a way as always to produce the same strength of current, no matter whether there are 300 lamps alight in each conductor, or only 10.

Let us now compare this system with the only other system in which glow lamps are arranged quite independent of each other, leaving out the consideration of secondary generators. In the parallel system the central station must be in the centre of the district to be lighted, which is often very objectionable, and sometimes impossible. In the series system the station may be far out of the way. In the parallel system we are restricted to the use of a 100-volt lamp, as we have seen before, and, in consequence, the radius of the district to be lighted must be kept very small, or the expenditure for conductors would be prohibitive. In the series system the expense for conductors is comparatively small, and we may reach any distance. The parallel system requires that a fixed difference of potential should be maintained in all the conductors under varying strength of current—a condition with which it is even theoretically impossible to comply, and which entails enormous practical difficulties. In the series system we have to maintain a constant current under varying resistances—a condition which can be easily fulfilled. When the parallel system was first developed, the prevailing idea appears to have been to make electric lighting from central stations similar to gas lighting. But the conditions under which electrical energy in its active form is best transmitted are so different from those requisite for the transmission of the potential energy of gas, that the desire to imitate the gas system has proved rather a disadvantage.

We now arrive at the last, and perhaps the most difficult, part of the whole installation, viz., the outfit of the place which is to be provided with lamps. For the sake of simplicity, I will suppose the place to consist of one single room, as shown in the sketch. In this sketch the small circles marked L, represent lamps; the squares marked S, represent switches (which will be presently described); and the cross marked V, is to indicate a

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registering voltmeter. The street main, M, enters the house at the main switch, drawn larger than the others; it continues from switch to switch, and returns to the main switch before leaving the house. We have supposed the street mains to be composed of No. 6 copper

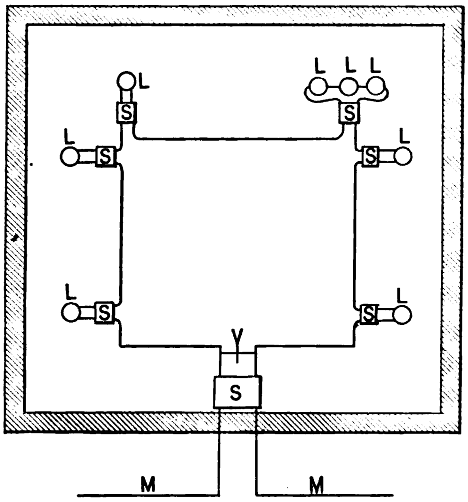

FIGURE 3.

wire, but the house mains may be made equal in section to No. 10 wire, in order to be more flexible. The lamps are always connected to their respective switches.

From what has been said before, it is quite evident that the first and essential condition of such a system must be that the circuit is never to be opened, whatever may happen. As we are always dealing with a closed circuit, it will prevent misunderstanding if we give a different designation to the two ways in which the circuit can be completed; and I shall, therefore, call the circuit "short-closed" if the current goes directly through the switch-lever, and "long-closed" if the current is led through the lamps or other electric devices, such as motors, which are to be acted upon. The fact that the circuit is never to be opened reduces one great difficulty in the switch required in the parallel system, viz., the liability to produce an arc.

The main house switch, to which I shall now invite your attention, serves the purpose of either short-closing the street circuit, so that no current can pass into the house, or of long-closing the same, thus including the house circuit into the main circuit. In the first case I have not considered it sufficient merely to prevent the current from entering into the house; I have thought it advisable to disconnect the house circuit entirely from the street circuit at the same operation, so that any alteration of the circuit may be made inside the house without the possibility of a branch current being established, even if the street circuit should be of defective insulation. But this switch is also made to answer another purpose. Supposing that the street circuit, which has been short-closed, is now to be long-closed, but that by some accident or another a break of the continuity of the line has occurred in the meantime inside the house; if now the switch-lever were to be moved with the intention of allowing the current to enter the house, the result would be the formation of a long arc, and eventually the whole current would be interrupted. The manner in which this has been rendered impossible can be best explained by reference to the annexed sketch, in which A is the switch-box, made of insulating material, and L the switch-lever, made of conducting material. C, D, and E are three pieces of metal let into the upper edge of the circular box. The lever L may occupy three positions, marked 1, 2 and 3. In position 1, C is connected with E, and as C is one terminal of the main circuit and E the other, this circuit is now short-closed. But if the lever L is in position 1, it lifts two flat springs of metal, F and G, which are the terminals of the house circuit, from their respective seats on the metal pieces C and E. The lever L carries on its upper side two pieces of insulating material, on which the two springs F and G now come to rest, and consequently the house circuit is out of all electrical connection with the main circuit.

If it were now intended to allow the current to pass into the house circuit, the lever L would have to be turned from position 1 to position 3; but when the lever passes over the intermediate position 2, it first connects the metal piece D with E. But the metal piece D is permanently connected with C by means of the resistance R, and the main current will therefore be divided in two parts—one, the greater portion, passing through R and L to E, the other, the smaller portion, passing through the house circuit in case the same is complete. This house circuit includes the electro-magnet K, which is situated inside the switch, and the armature of this electro-magnet carries a pin, P, which is in such a position that it is below the plane of the motion of the lever L if the armature be attracted, but hinders this motion if the armature be not attracted. In case, then, that the house circuit is complete, there will be no impediment to the further motion of the lever L from position 2. It will therefore reach position 3, where it rests upon pieces of insulating material, and the whole current now passes through the house circuit. But if the house circuit had not been completed, the motion of the lever would have been arrested by means of the pin P, and a break in the circuit is in this way made a matter of impossibility.

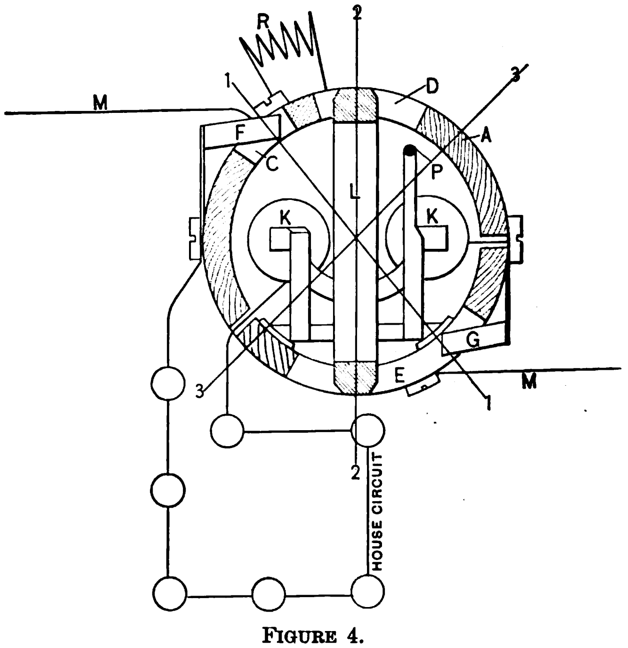

FIGURE 4.

I shall pass at once to the lamp switch, because it is practically a mere repetition of the main switch on a smaller scale. But the lamp switch contains an additional arrangement, which would be a useful adjunct to the main switch as well, viz., the automatic cut-out. This is intended to act if the lamp should fail during the passage of the current, in which case the break of the circuit is prevented by short-closing it around the lamp. The arrangements which I have used to provide for this eventuality are of two kinds, and may be shortly described without reference to any drawing. Both are based on the principle that if the resistance of the lamp increases—which always occurs in lamps placed in series when the carbon gives out and an arc is formed—then a current in a shunt around the lamp will increase. In one of these arrangements this increased

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current is made to act upon the armature of an electro-magnet, which armature releases a spring for the purpose of making a direct secure contact between two places of the circuit in which the lamp is situated, and a short circuit is thereby formed round the lamp. In the other arrangement a fusible wire is placed in the shunt, and a lever is arranged in such a way as to be acted upon in one direction by the wire, and in the other by a strong spring. If the wire fuses, the spring presses the lever against contact pieces, which serve the same purpose as specified above. In neither case can the circuit, which is now short-closed, be made to include the lamp again until the cut-out lever has been moved into its former position by hand. The combination between the switch and the cut-out lever is such that the switch-lever has to be placed into position 1 before the cut-out lever can be operated upon by hand. The reason for the adoption of this last arrangement will become evident by a consideration of the peculiarities of the switch which I have mentioned before. I believe that in this way I have provided for the prevention of a break in the circuit which may occur from any eventuality.

I need not dwell on the construction of the lamp holder, the only part of the outfit which has not yet been mentioned. It may be made in different ways, but one principal idea has been adhered to in its design, as well as in that of all other details which constitute the outfit of a house: there is no part conveying a current which is not perfectly insulated, or which is in any way exposed so as to offer the possibility of any person coming into contact with it. This is hardly possible in arc light circuits, but may easily be done where only glow lamps are used.

And this brings me to the last question which I shall have to consider, namely, the question of safety. Here again I shall have to note one very great advantage of the series system over the parallel system, and this is the impossibility of a wire becoming overheated. Every experienced electrician knows as a fact that short circuits in the parallel system have often led to detrimental results in spite of safety fuses; and a system in which such a danger does not exist, and which consequently does not require any provisions against it, has certainly much to recommend it. Especially in such cases in which the danger of fire must be most dreaded—in ship lighting—I believe that this advantage of the series system will be very greatly appreciated.

I now come to the objection generally raised against the use of high-tension currents. If an inventor were to appear to-day saying he wanted to introduce into our houses a substance which, when properly used, was intended to give light, but which in itself was a poison, and produced poisons when used as a light, and of which it was further known that it was always ready to form an explosive agent when mixed with atmospheric air, I believe that the critical spirit of our time would raise an outcry against the introduction of such a dangerous substance, and against the use of the public streets for its conveyance. But this substance—of which we know that it is quite harmless as long as it is retained within metal tubes—is now actually carried into all our houses, and we are so familiar with its peculiarities that no one feels any nervousness nowadays in the neighborhood of a gas chandelier.

In conveying a high-tension current into a house we are in a far more favorable position than if dealing with gas, because the probability of an accident is far more remote. Three conditions must be fulfilled before any person can be injured by an electric current. First, there must be a certain amount of leakage on the line; secondly, the person must be in contact with a bare conductor; and, thirdly, the person must at the same time be in contact with the ground.

In the system of central lighting which I have laid before you it is easy enough to constantly ascertain the condition of the line, and far easier to locate a fault than in a complicated system of branch wires. It is, further, easy to construct all parts of the system inside a house in such a manner that contact with a bare conductor is impossible; and, moreover, a person standing on a carpet and a dry wooden floor is exceedingly well insulated. The tension which we can use with safety depends simply upon our means of insulation. If you will recall the precautions which have been taken in the construction of the switches by entirely disconnecting parts of the circuit from the main circuit, when lamps have to be replaced or alterations to be made in the circuit, then I think you will agree with me that the probability of an accident is exceedingly remote; and this system of lighting appears to offer more safety than any other method of artificial lighting at present in use.

And now, in conclusion, I should like to say that in a short paper like this which I have had the honor of reading to you, I found it impossible to enter more fully into details than I have done, and I have therefore restricted myself to the explanation of those details and the discussion of those questions which appear to me of prominent importance. I hope that by my humble efforts I may have accomplished the object of my labors, namely, the further extension of the field of electric lighting.

DISCUSSION.

Mr. Preece said none but those who who have actually had the electric light fitted in their houses can possibly have any idea of the great advantage and comfort of this method of illumination. The introduction of the electric light into dwelling houses, he contended, would do more good than any of the arrangments suggested by sanitary institutes. He objected to the use of the word "strain," as applied to the number of watts per candle at which a lamp was worked, especially as the term was very ambiguous in its meaning. Mr. Bernstein had laid great stress upon the fact that high resistance filaments are very well in their way, but that they are very expensive. What we want is cheap forms of lamps worked at a high power for a moderate period—say, 200 hours; such lamps would probably be the most economical in the end. A great point about the series system of working lamps was the non-liability to short circuiting. This short circuiting was a most serious matter in the case of the parallel system. He had come to the conclusion that there were as many dangers in electric as in ordinary methods of lighting unless proper care was exercised in putting up the installation. The result of a main breaking down in the series system was a point which must not be overlooked. He considered Mr. Bernstein's paper was one of great interest.

Mr. Rawson said that with reference to the construction of incandescence lamps, they had to rely to a great extent upon secrecy in the matter, and he could not, therefore, say much as to his own experience. He would ask how joints would be made in a series system in which the current had continually to be kept on, as it must be in some installations. He thought it a pity that the use of accumulators had not been mentioned. The question of the occluded gas in the mounts of the filaments was, he thought, a difficulty which had to be got over. Did the lamps alter in resistance from use? He thought that safety junctions ought to be placed at every lamp, and not at every room only, as advocated by Mr. Preece in his paper before the Society of Arts. With reference to the "flaming" mentioned in the earlier part of the paper, he thought that this was due to the vacuum being imperfect. The temperature at which the lamp was burnt was, he considered, too high for durability. The question of short circuits from leakage in the series system, due to accumulation of moisture, was, he believed, a much more serious difficulty than might generally be imagined,

Mr. R. E. Crompton pointed out that Mr. Swan, when he first took up the manufacture of incandescence lamps, had intended to work on the same lines as Mr. Bernstein had; but he (Mr. Crompton) had dissuaded him from doing so. He thought the difficulties in connection with the series method of working were enormous; if double earth faults occurred, the system will be very dangerous—indeed, he doubted whether the Board of Trade would sanction the use of the high potential necessary for the system. Short circuits through the body took place often in a most unexpected way. He differed from Mr. Bernstein as regards the high efficiency of lamps; he considered 50 and 110 volt lamps to be equally good. A good Swan lamp should last 2,000 hours at full candle-power. The double mouth required in the Bernstein lamp presented a difficulty, as it did not admit of so elegant and neat a suspension as in the case of the ordinary lamps. The constant current question, which was a vital one in the case of the series system, was one of extreme difficulty; the constancy had been attempted to be

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effected by means of an electrical governor, but not with perfect success, as a change in the number of lamps in the circuit produced a perceptible effect upon the others. It was far easier to keep the potential than the current constant. He thought the author's reference to occluded "oxygen" in the filament mounts to be a mistake, as he had heard of occluded hydrogen but not of occluded oxygen; the phenomena observed must, therefore, be due to some other cause than that suggested. The jumping across which was stated to take place in lamps when others were switched off was a phenomenon which never took place now that lamps were properly made. In conclusion, he expressed his opinion that the light from the large filament was in no respect superior to that from the ordinary fine filament.

Mr. Mortimer Evans explained that the economy of the light from an incandescence lamp greatly depended upon the radiation from the bright surface, and this depended upon the nature of the carbon. He thought that an economy of two watts per candle ought to be obtained. A point to be remembered was that with large lamps the electromotive force might be as high as we pleased; the difficulty was to get small lamps with a high electromotive force. Any improvement in brightening lamps must be in the direction of lowering their electromotive force; it was not advisable to raise the temperature.

Mr. Drake agreed with Mr. Crompton as to the difficulty of keeping a constant current; he knew of no regulator which would effect the desired result properly, because it was necessary that a change should take place before the regulation could be effected. He thought that safety appliances absorbed too much power. Resistances were, he considered, very liable to derangement.

Prof. Forbes thought that the shunt difficulty had been solved by Mr. Bernstein, but the expense of the arrangement was, he considered, rather a serious matter, the great saving which would result in the conductors, might, however, more than counterbalance this. If it could be proved that the lamps were durable there were many cases in which the series system would be used with great advantage. As regards the constant current difficulty, quite irrespective of compound winding, he would point out that in America the principle had been carried out to a great state of perfection; this was especially the case in the Thomson-Houston system. Weston also had been successful in the matter. One great advantage of the series arrangement was its safety; he affirmed this in spite of what Mr. Crompton and others had said on the subject. No short circuiting could occur as in the parallel system. Earth faults could be avoided by constant testing and cutting off the houses in which earth faults were found; the locality of a fault could be much easier traced in a series than in a parallel system.

Sir David Salomons found that the 50-volt lamps became blacker much sooner than did the 100-volt lamps, a result due to the fact that the area of the glass was smaller in one case than the other. No arcing should take place if the vacuum were good. He had run his installation for 2½ years without any arcing taking place. He employed the parallel system, and it had given no trouble whatever. He thought that there was a considerable amount of power lost outside the filament itself. Switches ought to be made of china or some other incombustible material.

Prof Ayrton said that the cost of renewals of lamps was an insignificant item in the total annual expenses, taking the cost of the lamps at 5s. per 1,000 hours. The danger question was much exaggerated; a potential of 2,000 volts would not necessarily kill anyone provided the current were continuous, the danger was from want of continuity; the use of a great number of commutator bars and symmetry of make would avoid this. The constancy of the current in the Thomson-Houston system was obtained by a regulator which moved the brushes. He was inclined to think absolute constancy of potential was the most difficult to obtain. A great point in the low-resistance lamp was that in the case of temporary installations a few cells (though possibly of large dimensions) only would be required, the electromotive force required being low. With reference to the use of the word "strain," he thought that "efficiency" much more exactly expressed what was meant.

Prof. Silvanus Thompson considered that a constant current system avoided many difficulties, that of self-induction for instance. It was a curious fact in the Thomson-Houston system that the lamps became perfectly regulated when a number of others were cut out of circuit before the brushes had taken up their final position. The statement that a low resistance lamp was less economical than a high resistance one was, he thought, absurd, as a large hollow filament was nothing more than a bundle of thin filaments joined up in parallel arc.

Col. Webber asked how the platinum of the Bernstein lamp was secured to the glass, and also what was the quality of the latter.

Mr. R. E. Crompton drew attention to a point which appeared to have been overlooked in the question of constant current regulation, and that was, that in the Thomson-Houston system arc lamps were used, which were in themselves regulators.

The discussion was then adjourned.

THE INSTALLATION AND MANAGEMENT OF ARC LIGHTING PLANTS.

BY J. M. ORFORD,

Superintendent of the Bridgeport (Conn.) Electric Light Co.

CHAPTER I.

THERE is scarcely a city in the United States or in the Dominion of Canada, having a population of 40,000 or more, in which there is not a local electric lighting company, more or less profitably engaged in the illumination of the streets, stores, public buildings and hotels with the arc light. It is susceptible of demonstration that there are also a large number of towns and cities, ranging in population from say 10,000 to 40,000, where the electric light could also be used with great advantage and convenience to the citizens, at the same time earning a handsome return on the actual necessary investment of capital. In fact it is probably owing to a general conviction that a small arc light plant is not likely to be a very profitable investment, that has hitherto deterred capitalists from entering this particular field. It would perhaps be too much to assert that a small plant can in any event be run at approximately the same cost per lamp as a large plant, but experience has demonstrated that with a fair start, and more especially with a judicious and intelligent management, a very satisfactory dividend can be earned on capital invested, even in a comparatively small plant. There is really no valid reason why every town of 10,000 or more inhabitants should not have a successful and profitable arc lighting system, and this is true under favorable circumstances even in towns of smaller size.

It is almost superfluous to call attention to the many advantages which the class of cities, towns, and villages referred to will derive from the introduction of a well designed and efficient electric light system. Real estate owners would invariably find their property considerably enhanced in value, while all other interests of the locality are more or less favorably affected. The writer can point to a place not many miles from New York where a private citizen established a plant, having in view simply the general idea of improving the neighborhood and rendering it attractive. His undertaking has not only been successful in this respect, but perhaps somewhat unexpectedly, has proved very profitable to himself. His electric light plant is not only earning a good profit on his investment, but his real estate and other property in the neighborhood has largely increased in value. It is needless to say that if this result can be accomplished in one place, there is no apparent reason why it cannot be done elsewhere.

With this end in view, we propose to lay before our readers a series of articles, which shall be a practical treatise on modern arc lighting in its various aspects, so that any persons desirous of undertaking an electric lighting scheme, may learn the nature of the peculiar obstacles and difficulties liable to be encountered, how these may be most successfully surmounted or avoided, and what amount of profit may reasonably be looked for if the enterprise is judiciously managed. We think, moreover, that the officers and managers of electric lighting enterprises already in active and more or less successful operation, may find it no disadvantage to consider some of the points which we propose to discuss, reserving their own judgment as to what extent they may find it advantageous to adopt our suggestions.

There appears to be no sufficient reason why all electric lighting companies, or at least all arc lighting companies should not earn satisfactory dividends. When this is not the case, we advise the owners or managers to lose no time in consulting a competent electric light engineer, and have him point out the source of the trouble.

The story is told that the council of one of the most enterprising cities in the southern states decided to bore an artesian well for the purpose of supplying the city with pure water. The contract was accordingly made with a

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military personage of the vicinage, and under his directions twenty or thirty thousand dollars of the citizens' money was expended in boring a hole into the interior of the earth's crust, without any other effect than to exhaust the funds set apart for the work. The city fathers then bethought themselves to consult a geologist to ascertain the probable cause of the difficulty. He, for a small fee, informed them that their city was located on a primitive geological formation, and that they might bore through to China if they pleased without the least danger of finding any water. The moral of this story is obvious.

We do not undertake to say that it is an easy matter to construct a lighting plant which will pay from the first day of going into operation. Among the local gentlemen, retired capitalists, successful grocers and dry goods dealers, from whom the sinews of war are usually gathered, there is certain to be one individual who wants to boss the job. He has a personal interest in some machine shop or factory, and he thinks he knows a little more than some others about engines, boilers and pipes. He would have you know that he has been eminently successful in his own business, and he entertains no doubt whatever, that under his general management the enterprise will be a great commercial success. A considerable experience in different communities of this class leads us to state as a fact that this energetic gentleman is finally permitted to have his own way. His associates are aware that they know very little about it and they finally are brought to believe that the other man does, mainly because he says so. The inevitable result is that the company is very fortunate if, after the lapse of a year or two, it does not find itself handicapped with an expenditure of from 10 to 50 per cent. more capital than would have been required under intelligent and rational management.

We, therefore, would lay down the following proposition: —If you propose to build an expensive house, you consult an architect; if you propose to go into the electric light business it is far more important that you consult and be guided by the advice of an electric light engineer.

The problem being given to equip a central station for arc lighting having a maximum capacity of say 50 lights, the first thing is to select from some one of the considerable number of excellent systems now used in this country, two 30-light dynamos and 60 lamps. It is no part of our plan to advertise or recommend for adoption, in preference to others, any particular system, but we may be pardoned if we call attention to a few important points which should by no means be overlooked in making a selection. In the first place select a dynamo which is known from practical experience to be efficient and durable. We do not mention economy in this connection, because an efficient machine must in itself be an economical one. A convenient and satisfactory way to test its efficiency is by ascertaining, by means of a dynamometer or indicator diagram, how many horse-power are absorbed in maintaining 30 good-sized bright lights. Certain makers claim that their dynamos will give a 2,000 candle-power light with $\frac{1}{10}$ of a horse-power. Observe particularly whether the machine is capable of regulating its own current when the lamps on the circuit are cut in or out at the option of the customers. If the machine is unable to do this without more or less assistance from the attendant, it may safely be stated that it is not altogether so efficient as it might be. If you visit some electric light stations, a considerable number of lamps may be observed burning in and about the station, in order to aid in making up a certain number of lights in the circuit, in the absence of which the machine gives trouble. It is almost needless to say that this is a good style of machine to have nothing to do with. The best way to be certain of the behavior of any practical machine under these circumstances is to try it for yourself. Start with 30 lights on your machine, have them where you can mind them or otherwise be sure that they are all there, then cut them out two or three at a time, until they get down to three or four. Then cut them in, in as rapid succession as possible, until all are in operation. If the dynamo during this time has pursued the even tenor of its way about as usual, and no sensible increase or decrease in the light emitted by the lamps actually burning has been observed, and no one has assisted the machine or any regulating apparatus connected with it, proving that the regulation is automatic beyond a peradventure, then you cannot be far wrong in choosing such a machine.

It will be well to institute inquiries wherever reliable information can be obtained as to what repairs to the dynamo are likely to be needed during a year's constant running. If repairs are frequent and expensive, it may be assumed that something is at fault in the construction. It will not do in all cases, however, to hastily conclude that this is the case; it is not uncommon that a good machine is subjected to frequent and expensive repairs by reason of unskillful and ignorant management, but as a rule it is not difficult to gain reliable information as to the reputation of different machines in this respect.

In choosing a lamp it is preferable to select one where the mechanism is actuated by the electric current alone. In some forms of lamps springs are attached to assist in the operation of raising the rod and carbon. Experience shows that they are not a desirable feature. A well-designed lamp does not require springs, either for assisting the armature or adjusting the lamp. Springs sooner or later are pretty sure to make trouble. And another piece of advice: get a lamp which, when once adjusted and regulated to operate properly on a given current, shall under no circumstances require readjustment when again operated by an equivalent current.

The next thing requiring consideration is the motive power. For a small station experience leads us to advise the employment of a 60 h. p. engine, adapted to run at such a speed that no shafting will be required. Run the belt direct from the engine to the pulley of the dynamo. The question of the boiler is also an important one. It seems almost trivial to say that it should be so constructed as to obtain the best results from the fuel used, yet nothing is more common than to see this vital point neglected or forgotten. A boiler of large capacity is the cheapest in the long run. Let it be capable of generating considerably more steam than is actually required in the work to be done. The most economical results are always attained when the engine and boiler are not forced to their maximum capacity. A suitable heater is also requisite, of which there are many excellent kinds. There will also be required steam pipes connecting the engine and boiler and a feed pump.

Outside the station there will be required say 60 poles, each 30 feet long, with the necessary cross-arms and insulators. Four or five miles of copper line wire of No. 8 new standard gauge. Common glass insulators are generally employed, the same as those used by the telegraph companies. If it were possible to procure them in this country at a reasonable figure, the large double bell porcelain insulators used on the French telegraph lines would be incomparably superior. It would be a desirable thing if some of our enterprising dealers would import a supply of these insulators for this especial purpose. In any event the total increase in the cost of the plant would be insignificant, as the number of insulators used is so small.

In such a plant as we have outlined, there would be say 40 commercial lights and 10 municipal lights, or perhaps, in some cases, more of the one kind and less of the other. The municipal lights ought to be suspended over the centre of the street, clear of the tree branches. In order to do this a mast-arm will be required for each of these lamps.

Having thus given a general idea of the constituent elements of the plant, we have first to consider the question of cost. The different manufacturers will furnish their price

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list on application, but it will be found that the prices vary considerably. It may be necessary to pay for the first cost of the outfit of dynamos and lamps, at the rate of from $120 to $150 per lamp. These figures ought to embrace everything required for the regulation of the dynamo, as well as appliances for the shifting of the position of the dynamo to suit the tension or run of the belts, hanger boards, and hoods for the lamps, and cut-outs to be placed where the wires enter buildings. The glass globes you may purchase for yourself, the present price being about $6 per dozen. A good 60 h. p. steam engine, boiler, heater and pump placed in position and connected with the necessary pipes, may cost as much as $3,500. A careful and well-informed person may manage it as low as $3,000. Good 30-feet poles, with cross arms, set in position, and painted, will cost $6 each. Mast arms for municipal lights, $14.50 each. Line wire, and stringing the same, $100 per mile. By the time the lamps are placed in circuit, the wiring, rubber tubing, porcelain knobs, screws, etc., together with labor, will cost, say, $4 each. A switch-board will be required, also a magneto-bell for testing, say $40. It will make the whole foot up about as follows :

Engine, boiler and fittings	$3,500
Two 30-light dynamos and 60 lamps	9,000
Poles	360
Mast arms	145
Line wire	400
Hanging and fitting lamps	200
Switch-board for central station	40
Spare armature	800
Belting	50
Total	$14,495

There will necessarily be some legal and other similar expenses in organizing the company, so that it will not be amiss to say that the cash capital actually required to establish a company with a plant such as has been described, will not be less than $15,000. We may safely assume, therefore, that a 50-light plant and central station can be equipped with the best that is to be had in the market, and everything made ready for the steam to be turned on and the lights started, for $15,000. The cost of equipping a larger station will be nearly in the same proportion ; a plant of 100 lights will cost about $30,000, and so on.

It will be observed that although the estimates have been based on a 50-light plant, provision has been made for 60 lamps. The advisability of this will be apparent from a consideration to be hereinafter stated.

The next question for consideration is in respect to the income which may reasonably be looked for from this plant. Experience under various circumstances, obtained in practice, has shown that 20 lamps ought to earn an average of $120 each per year. Thirty should bring in $150 each per year. The difference arises from the necessary classification of the lamps dependent upon the average number of hours of service. The total income from both classes of lamps will therefore be $6,900. The $120 lamps ought not to be run after 10 P. M. It may be assumed that the remainder will be run until midnight. The prices given are low, perhaps lower than the average prices now obtained, taking the country through.

The operating expenses will be, approximately, as follows :

Salaries and labor	$1,825
Fuel and water	1,095
Carbons	360
Oil and waste	120
Globes	45
Rent and taxes, or interest on real estate	360
Contingent expenses	300
Reserve fund for depreciation or renewing of plant	750
Total	$4,855

The above being deducted from the receipts leaves $2,045 of the earnings applicable for dividends. The above estimate is made on the assumption that all the lights are 2,000 candle power.

In the foregoing calculations we have assumed the dynamos to be of a capacity for 30 lights. In explanation of this, it should be remembered that the station ought to have one light in the boiler room, and another in the machine room, and, as a rule, it is not out of place to have one outside the station by way of advertisement. In every community opportunities frequently occur for placing temporary installations of a few extra lights in halls and other places for private and public entertainments, on which occasions the company is very well paid for its trouble. Moreover, the usual experience is that the number of customers increases with great rapidity. At first there is a large class of people who wait to see how it works in their neighbors' places before venturing to order it for themselves.

It should have been mentioned in the proper place, that by using a large boiler a cheap form of fuel may be advantageously used. In the estimate allowance has been made for the best of everything, so that the setting of the boiler should be of the most approved modern form.

A lamp of 1,200 c. p. has quite recently come into use, which is giving the utmost satisfaction both to the company and the customer. A dynamo suitable for operating this class of lamps can be purchased for a less price per lamp-power than one designed for 2,000 c. p. lamps. A 30-light 2,000 c. p. dynamo may be converted into one of 45-lights and 1,200 c. p., by winding with wire of a smaller gauge. The cost of manufacturing such a dynamo is about the same and the selling price should be little if any more. Hence it follows that the amount of money required for two 30-light dynamos of 2,000 c. p. will be sufficient to furnish two dynamos having a capacity to supply 90 of the 1,200 c. p. lamps. The power required to run each class of dynamos is the same. The carbons for a 1,200 c. p. light will also cost less than for a 2,000 c. p. light. Hence the economy of the smaller lamp is not only in the first cost, but is constantly realized ever afterwards in the reduced cost of operating.

It will be apparent from what has been said, that a company can afford to run a 1,200 c. p. lamp for considerably less money than a 2,000 c. p. lamp, and the consequent reduction in the rental brings the cost of lighting within the reach of many customers who could not afford to use or pay for a 2,000 c. p. lamp. It would be safe to say that the number of consumers increase very considerably if the price of the light could be reduced 20 per cent. below the sum ordinarily charged. The objection may be made, that the volume of light is correspondingly less. Of course this is true, but at the same time the illumination is ample for the size of stores found in many of our towns, and even in large wholesale houses, a greater number of the small lamps may be put in, and better results obtained for all practical purposes without increasing the cost. A subdivision of the light evolved by the white, glaring 2,000 c. p. lamp is very much to be desired, and the 1,200 c. p. lamp is a step in the right direction.

Even in street lighting the small lamp is not without its advantages. The price per lamp being reduced more of them can be placed in a given street, and a better distribution of light secured at the same time. We would therefore strongly recommend the adoption of the 1,200 c. p. lamp for all purposes, the lighting of stores and streets alike.

Electric lighting by means of the arc lamp has already become popular in this country, but it ought to become more and more so from year to year, and in order to bring about this result it seems certain that a smaller and less expensive light will have to be adopted.

As we have seen, therefore, an investment of $17,000 to $18,000, will establish a plant having a capacity of 90 1,200 c. p. lamps. The operating expenses will not exceed $5,500

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per annum, and the income ought to be, on 45 lamps at $100 per year, $4,500, and on 40 at $125 per year, $5,000, making a total of $9,500. This would give a net profit of $4,000, which is by no means a bad showing on a capital of even $20,000.

With such a plant as we have suggested, the result will be that the customer will be well satisfied with the light, and with its cost, while at the same time the company will be able to earn a good dividend on its capital.

The figures which have been given are based upon actual experience, with the exception that the income is less than it really is in most places, and the allowance for expenses and incidentals is ample. By close figuring in various directions, which will suggest themselves, a considerable saving may be effected without impairing the efficiency of the service. The receipts and expenses have been figured on a somewhat conservative basis, as it is not desired to make statements of results which cannot be realized by intelligent and energetic management under ordinary circumstances.

In order to attain such results, it is imperatively necessary that a proper start be made. Many companies have crippled themselves for life, so to speak, by adopting dynamos, engines, boilers and other appliances which are wholly unfit for the work required of them. It is only after one or two years experience that a company in this condition gets into a fair way of earning enough to justify the payment of a dividend, and by that time it requires considerably more money to pay it. Through mistakes which have been made here and there the capital account has gone on increasing, more money being required to remedy first one error and then another. It is only necessary to take a walk around a few electric light stations to convince an observant person of the truth of this assertion. That mistakes should be made in the first electric light stations was a matter which was of course inevitable, but there is no reason why these blunders of ignorance should continue to be perpetuated and even repeated, which unfortunately they still are *in starting some new stations.*

Having thus shown that there is money in the electric lighting business even on a small scale, we will next proceed to the discussion of the details respecting the location and equipment of the station.

(*To be continued.*)

TESTS OF SMALL DYNAMOS AND MOTORS.

REPORTS BY PROFESSOR ANTHONY AND LIEUT. MURDOCK.

Test of Hand Dynamos.

At the request of Messrs. James W. Queen & Co., I tested some of the hand dynamo machines for which they are agents. The attempt was made at first to use ordinary instruments, tangent and potential galvanometers, but it was found that the irregularity of the current prevented any accurate observations, and it was impossible to turn the cranks with sufficient regularity to produce a current which could be measured. The plan was then adopted of measuring the external resistance, and determining the current by a Deprez ammeter. The resistances used were of german-silver, several being attached to the frame of one of the Fein machines. Three others, each of about six ohms resistance, were used.

It was thought that the best method of testing would be to obtain as far as possible, the maximum output of the machines, and the observations were therefore made under these conditions. The crank was turned as rapidly as possible, and the maximum current was observed. The results thus obtained, were of course higher than could be kept up for any length of time, but in most of the machines the test was also made under the usual working conditions.

The two when combined give the maximum which can be obtained, and the ordinary work which can be depended on.

The resistances heated very slightly, owing to the short time that the current was passed through them.

The ammeter used had been calibrated at the test house and found to be in general in excess about three per cent. This correction was applied to all observed currents. Currents below two and one-half ampères were measured by another ammeter, graduated to tenths of an ampère. No correction was applied to the readings of this instrument.

The above applies to all machines tested.

Two machines were exhibited by C. & E. Fein, the No. 3 and No. 10.

The No. 3 gave the following results :

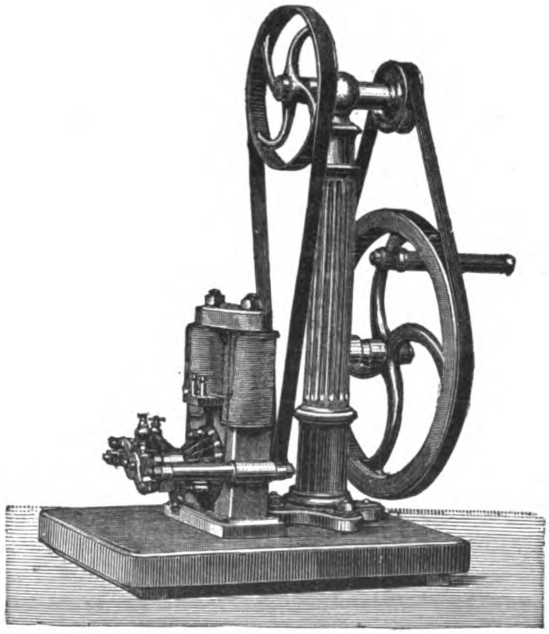
Armature resistance, ...	35
Field "	26
Total, ...	61 legal ohms.

Current.	External Resistance.	Difference of Potential.	Total Resistance.	E. M. F.
10.5	.9	9.45	1.5	15.75
10.1	1.1	11.1	1.7	17.2
8.9	1.5	13.3	2.1	18.7
7.6	1.85	14.1	2.45	18.6
6.5	2.8	18.2	3.4	22.1
3.7	5.0	18.5	5.6	20.7
1.65	7.3	12.0	7.9	12.9
1.25	8.9	11.1	9.5	11.9
.50	14.4	7.2	15.0	7.5

The results may be taken as the best capable of being obtained by a man of average strength. The best continuous working is about one-half the above E. M. F. for any given resistance.

The makers make the following statement in regard to the capacity of this machine.

It is capable of melting a steel wire 250 mm. long and ½ mm. thick. It will make a platinum wire of 500 mm. in length, and ½ mm. thick, incandescent. It will evolve 150 cubic cm. of water gases per minute. It will deposit 280 milligrams of copper per minute.



C. & E. Fein's Hand Dynamo.—No. 3.

The arrangement of this machine appears to be good, and quite compact, with but small weight for its power.

The second machine, exhibited by C. & E. Fein, was a No. 10, model 1 b. This machine was the most powerful one tried, and was operated by two men on separate cranks.

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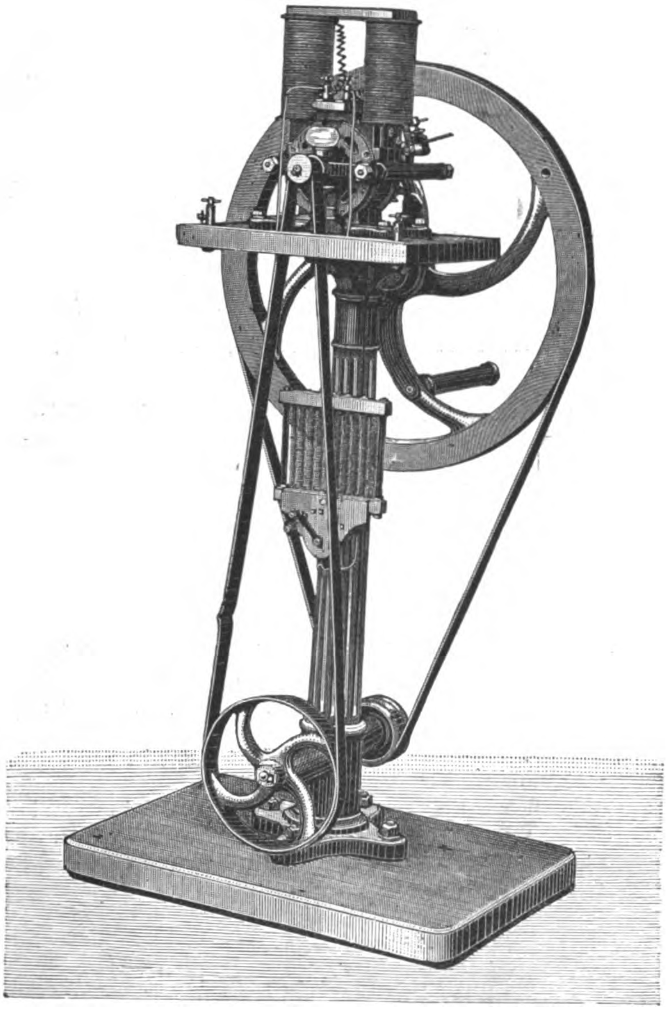
It has attached to its frame a set of german-silver resistances, which affords the means of modifying the external circuit at will. Some difficulty was found at first in exciting the field, but when the machine once worked it gave



C. & E. FEIN'S HAND DYNAMO.—No. 10.

very good results. The same method was pursued in obtaining the maximum output. The results were as follows:

Armature resistance,	....	6.32
Field "	....	8.82
		15.14 legal ohms.

	Current.	External Resistance.	Difference of Potential	Total Resistance.	E. M. F.
Maximum work with two men.	4.9	.9	4.4	16.0	78.4
	4.8	1.1	5.3	16.2	77.8
	4.9	1.5	7.3	16.6	81.3
	4.0	8.9	35.6	24.0	96.0
	3.7	15.7	58.1	30.8	114.0
	3.6	22.3	80.3	37.4	134.6
	3.3	28.6	94.4	43.7	144.
Continuous working, two men.	2.0	28.6	57.2	43.7	87.4

As illustrating the uses of machine No. 10, the maker states that it will melt a steel wire 1 metre long and 0.15 mm. thick. It will make incandescent a platinum wire 2 metres long and 0.15 mm. thick, and it evolves 150 cubic centimetres of gas per minute. It will deposit 250 milligrams of copper per minute.

This machine is of such capacity as to admit of demonstrating almost anything which can be expected of a dynamo machine. As it is capable of being worked by two men, its output is very large, and as seen by the figures of the test, it would bring to normal incandescence for a short time five ordinary Edison lamps, and would maintain several lamps of low potential, when worked continuously by two men.

The preceding machines are made wound with either coarse or fine wire. No. 3 machine tested, was wound with coarse wire, and No. 10 with fine wire.

Another machine tested was a magneto-Gramme machine, from the Maison Breguet. It differed materially from the others apart from its being a magneto machine, in having a very small internal resistance, which would adapt it to a very different class of experiments.

Current.	External Resistance.	Difference of Potential.	Total Resistance.	E. M. F.
10.4	.95	9.88	1.01	10.50
9.2	1.15	10.58	1.21	11.13
7.1	1.55	11.00	1.61	11.43
5.4	1.85	9.99	1.91	10.31
4.7	2.75	12.92	2.81	13.21
2.4	5.05	12.12	5.11	12.26
1.75	6.40	11.20	6.46	11.31
1.30	7.90	10.27	7.96	10.36

No attempt was made to preserve a constant speed. One man turned the crank as rapidly as possible, and the maximum current was noted.

No. 2, A.—GERARD DYNAMO-ELECTRIC MACHINE.

Another machine tested was the Gerard, laboratory model, No. 0, with pulley and crank. This showed much less power than the others, being tested in the same way, with the following results :

Armature resistance,	....	1.32
Field "	....	4.93
Total internal resistance,	....	6.25

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Speed.	Current.	External Resistance.	Difference of Potential	Total Resistance.	E. M. F.	
2,600	3.5	.85	3.0	7.10	24.90	Maximum.
2,700	1.4	7.15	10.	13.4	18.80	"
3,500	1.0	13.75	13.8	20.0	20.0	"
3,200	.5	20.55	10.28	26.8	13.4	"
2,300	.7	7.15	5.	13.4	9.4	Easy working.
1,900	.3	13.75	4.1	20.0	6.0	"
	.25	20.55	5.1	26.8	6.7	

Reported by J. B. MURDOCK.

Report upon Small Machines (dynamo), submitted by James W. Queen & Co., and tested at the Physical Laboratory of the Cornell University, in January, 1885.

APPARATUS USED.

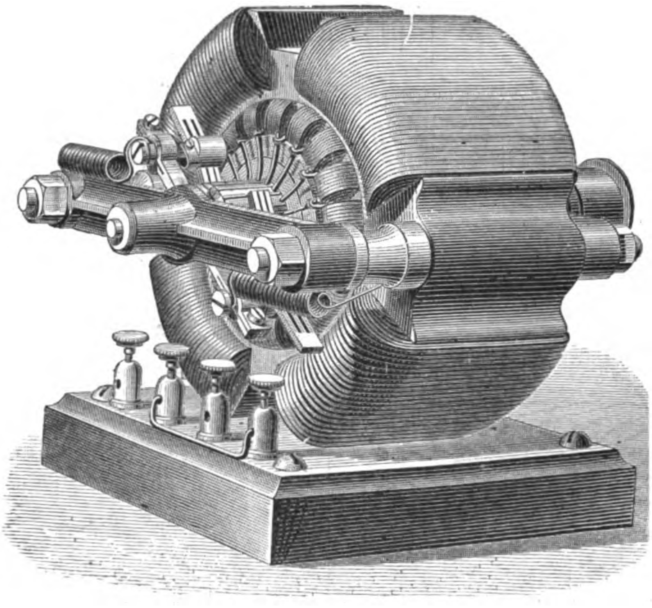
1. *Power Measurements.*—It was at first proposed to place the machines on a small Brackett cradle, but, as the adjustment consumes considerable time, it was thought best to use, as a motor, a Gramme machine, constructed ten years ago at the University, and which is mounted permanently on a very delicately balanced cradle. Having at hand a ten-light Weston dynamo, used for lighting the University campus, it was easy, using this as a generator, to obtain from the Gramme, as a motor, any power required, up to five or six horse-power. The Weston ten-light machine was provided with an adjustable resistance for the field circuit, which gave the most complete control of the current generated, and, therefore, of the speed of, and energy transmitted by, the Gramme. Under these conditions, the Gramme was a very easily managed and exceedingly delicate transmitting dynamometer. The speed of the Gramme was indicated continuously by a Buss "Tachymeter," but was also frequently taken by a speed counter, as well as the speed of the machine under test.

2. *Current Measurements.*—The currents were measured by a tangent galvanometer, whose conductor was a turned brass ring, fifty centimetres diameter, and a Thomson graded galvanometer. As *H* was not accurately known for the position of the tangent galvanometer, the constants of the instruments were determined by the copper voltameter. In the experiment for this purpose, two voltameters were placed in series, and the current continued for 100 minutes. Readings of the galvanometers were taken every four minutes. The extreme deflections were 40° 24′ and 41° for the tangent, and 31.6 and 32.7 for the Thomson. The deposit of copper was, in one cell, 10.477 grammes; in the other, 10.479 grammes; giving for the tangent galvanometer, 6.15 ; for the Thomson galvanometer constant, .1644.

3. *Resistance Measurements.*—Resistances were measured by means of a dial pattern resistance box, by Elliott Brothers, adjusted to B. A. ohms. Resistances have not been reduced to legal ohms. The machines were run on a dead resistance of german-silver wire wound on a reel, and so connected that it formed one branch of a Wheatstone's balance, the other branches of which could not be appreciably heated by the current. By this arrangement, the resistance could be measured at any time while the current was flowing.

4. *Potential Measurements.*—The potentials between the terminals of the machines were measured by means of a Thomson potential galvanometer checked by an Ayrton and Perry voltameter. The constants of both these instruments were determined at the same time as the constants of the current galvanometers, by noting the deflection when they were connected to each side of the german-silver wire, whose resistance was determined while the current was passing by the means described above. In these measurements the power may be considered accurate to about $\frac{1}{100}$; current to about $\frac{1}{100}$; resistance to about $\frac{1}{500}$; potentials to about $\frac{1}{100}$.

The readings of the various instruments during any test were generally very constant. If any considerable variations occurred, the test was repeated. Computations have been made independently by two persons, and it is believed that the results given are free from errors. In the tests of the machines, they were run at what was supposed to be the normal speed for some time, until instruments gave uniform readings, then readings were taken each minute for ten minutes. The resistance in the external circuit was then changed and another set of readings taken. Below are given the general results of the observations :



DE MERITENS' DYNAMO.

Small De Meritens' Machine.—Shunt wound, armature of the Gramme type.

Weight of machine, ... 68 pounds.
Resistance of armature, ... 1.36 ohms.
" " field, ... 70.7 "

Current. — *C.*	Potential at Terminals — *E.*	External Resistance — *R.*	Energy in External Circuit — *C E.*	Power given to Machine — *W.(Watts.)*	Commercial Efficiency — $\frac{C\ E}{W}$	Revolutions per Minute	Power Consumed *H. P.*
6.88	49.4	7.18	339.9	686.5	49.5	3,240	.92
6.54	37.1	5.67	242.6	553.9	43.8	3,200	.74
5.56	21.8	3.9	121.2	401.3	30.2	3,300	.54

It will be noted that this machine gave the greatest current with the greatest external resistance. The strength of field therefore diminished as the external resistance diminished. Possibly, better results as to efficiency might have been obtained with a still greater resistance.

The machine worked a Foucault lamp very well, but in order to start the lamp it was necessary to carefully separate the carbons by hand, as, with the small external resistance existing when the carbons were in contact, the machine would not excite itself.

NO. 230. CATALOGUE OF QUEEN & CO.

Small Gerard Machine No. 0.*—Shunt wound, armature of four pole pieces projecting radially from the axis. On each pole piece was a coil of wire. The commutator

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flashed badly at high speeds. Twenty-five hundred revolutions per minute was the highest speed it could safely run.

Weight of machine, ... 47 pounds.
Resistance of armature, ... .199 ohms.
" " field, ... 17.88 "

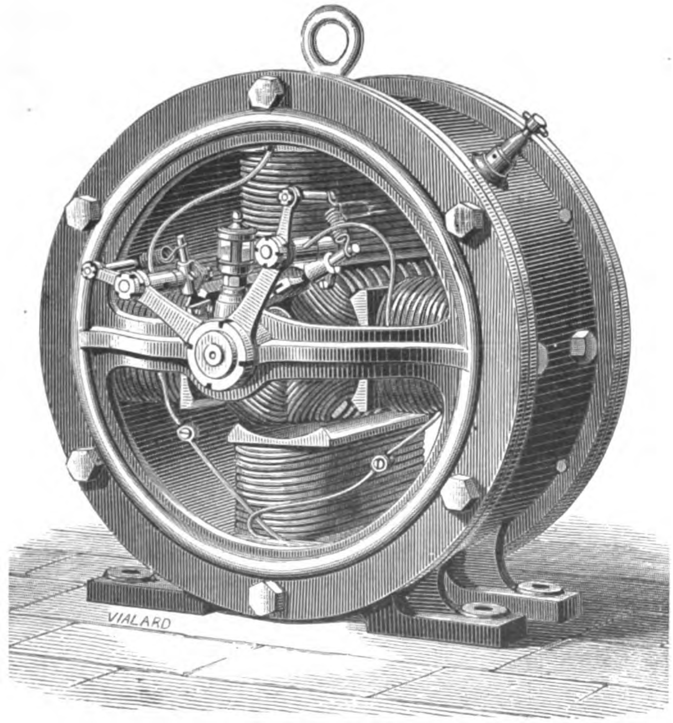
Current. — C.	Potential at Terminals — E.	External Resistance — R.	Energy in External Circuit — C E.	Power given to Machine — W. (Watts.)	Commercial Efficiency — $\frac{C E}{W}$	Revolutions per Minute	Power given to Machine in H. P.
4.09	29.04	7.1	118.8	381.2	31.2	2,350	.511
5.33	31.08	5.85	165.7	433.3	38.2	2,590	.581
7.33	28.62	3.9	209.8	433.3	48.4	2,500	.581
7.73	21.8	2.82	168.5	426.4	39.5	3,330	.572
Brushes readjusted and tension of springs increased.							
5.154	36.6	7.1	188.6	556.3	33.9	2,670	.745

NO. 234. CATALOGUE OF QUEEN & CO.

Large Gerard Machine No. 3.—Construction similar to small machine.

Weight .... 327 pounds.
Resistance of armature, ... .24 ohms.
" " field, ... 11.96 "

Current. C.	Potential at Terminals. E.	External Resistance. R.	Energy in External Circuit. C E.	Power given to Machine. W. (Watts.)	Commercial Efficiency. $\frac{C E}{W}$	Revolutions per Minute.	Power given to Machine in H. P.
10.76	80.66	7.94	867.9	2,585	33.6	1,356	3.47
10.39	71.3	6.86	740.8	2,443	30.3	1,390	3.27



Gerard Dynamo Machine.—No. 3.

To determine how much of the loss in this machine was due to friction and how much to induced currents in the mass of the magnets and armature, the brushes were thrown back and the machine driven at the same speed as in the above experiments. When the field was unmagnetized the power required was 147 watts = .2 h. p.

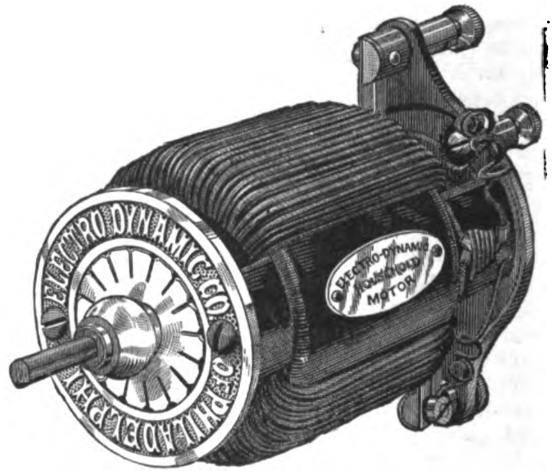
When field was magnetized by another machine having a potential of 54 volts, about three-fourths the potential of the Gerard machine, when magnetizing its own field, the power consumed was 830 watts or 1.11 h. p.

In the circular describing the above machine, the normal speed was given as 1,600. In my experiments, at any speed above 1,400, the flashing at the commutators was so great as to endanger the machine. Below 1,400 there was no flashing and the machine ran quite smoothly.

William A. Anthony,
Prof. of Physics, Cornell University.

Report upon Small Motors Tested at the Physical Laboratory of the Cornell University, in January, 1885.

These motors were submitted by James W. Queen & Co. from their exhibit at the electrical exhibition. They



Griscom Motor.

were a Griscom motor, a small motor of English manufacture, name not given, and an Ayrton & Perry motor. The power measurements of the first two were made by mounting the motor on a small Brackett cradle and causing it to drive a small machine which offered a resistance that could be varied at pleasure.

Current was measured by the Thomson current galvanometer, its needle in the most sensitive position, and potential by Siemens torsion galvanometer. The constants of these instruments were determined as described in the report on dynamos.

Griscom Motor.—
Weight, ... about 2½ pounds.
Resistance of field, ... .616
" " armature, ... .395

C.	E.	E C.	W. in Watts	Eff.	Revolutions per Minute.	W. in H. P.
3.81	7.84	29.87	6.86	23.	2,740	.0092
4.28	10.80	46.22	14.84	32.1	5,100	.0199
4.25	10.74	45.64	16.	35.	4,720	.0214
4.57	10.17	46.48	14.21	30.6	3,780	.0191

In this table and those that follow—
C = current through motor in ampères.
E = difference of potential between terminals.
CE = electrical energy supplied to motor in watts.
W = work delivered by motor in watts.

The other columns explain themselves. In the first experiment recorded above, the potential 7.84 volts, was supposed to be less than the normal potential for the motor. In the subsequent experiments a higher potential was therefore used.

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The motor ran during all the experiments very smoothly without sparking at the commutator, and without undue heating.

NO. 353, CATALOGUE OF QUEEN & CO.

S. P. Thompson Motor.—

Weight, ...
Resistance of field, ... .47 ohms.
" " armature, ... .373 "

C.	*E.*	*E C.*	*W.* in Watts	Eff.	Revolutions per Minute.	*W.* in *H. P.*
5.33	9.664	51.51	13.55	26.3	2,333	.0182
4.74	10.29	48.77	13.19	27.0	3,360	.0177
4.11	11.49	47.22	19.72	41.8	4,320	.0264
3.865	8.74	33.78	13.50	40.	3,000	.0181

Some trouble was experienced in keeping the brushes of this motor in the best order, It was only by frequent re-adjustment that so good work, as is shown by the above table, was obtained.

A commutator and brushes, well constructed, would make of this a very useful motor.

NO. 322, CATALOGUE OF QUEEN & CO.

The Ayrton & Perry Motor, submitted by Queen & Co., was tried, but before any considerable power could be obtained from it, the commutator caught fire and made it necessary to stop the machine. It was taken apart, put in the best order possible, without reconstructing it, and tried again. Again the commutator took fire, before anything like the capacity claimed for the motor had been reached. Two similar motors, belonging to the University, had been tried some months before with similar results. The commutator of one of these, said by the makers to be good for a potential of 100 volts, had been partly reconstructed in the University workshop. The spaces between the commutator strips had been filled with insulating material and the brushes remodeled. The armature also had been carefully balanced.

In this condition it was a far better machine than as it came from the makers. It was tested in place of the machine submitted by Queen & Co., and the results are given in the table below, as showing the best that can be expected from this motor, without a radical change in its construction. A higher electromotive force and higher speeds were tried, but with these there was a continuous flame at the commutator.

Weight of motor, ... 38 pounds.
Resistance of field, ... 0.57 ohms.
" " armature, ... 1.92 "

C.	*E.*	*E C.*	*W.* in Watts	Eff.	Revolutions per Minute.	*W.* in *H. P.*
8.34	59.75	498.32	141.9	28.5	1,500	.19

It should have been stated that the power delivered by this motor was measured, by making it drive a dynamo mounted on a Brackett cradle. The current of this dynamo could be perfectly controlled and, therefore, the power which it absorbed could be regulated at pleasure.

Wm. A. Anthony,
Prof. of Physics, Cornell University.

EXPERIMENTS WITH OIL AS AN INSULATOR.

BY H. C. FREMPT.

The oil used to insulate the underground wires running into the telephone exchange, at the corner of Broadway and Spring street, New York, is heavier than water. Take two cotton-covered wires which have been boiled in that oil, draw them through glass tubes, twist the ends together, and place them in an ordinary glass battery jar. Fill the jar half full of oil, after which water may be carefully poured into the jar and it will remain above the oil. Attaching the poles of a battery to each of these wires, as shown above the glass tubes, no current will be observed as passing from one wire to the other. See figure 1.

Take a piece of lead pipe containing a cable of cotton-covered wires insulated with the same oil in a fluid condition, and cut a hole in the lead an eighth of an inch in diameter, as shown at the point *a*, figure 2. The oil being viscous will ooze out slowly. Place the cable in a jar as shown, and fill the jar with water, the oil will continue to flow till an equilibrium is established, but no current can be passed from one wire to the other or from either wire to the lead pipe. Now, if instead of oil we use in this experiment paraffin, pitch, or rosin, the insulation immediately fails.

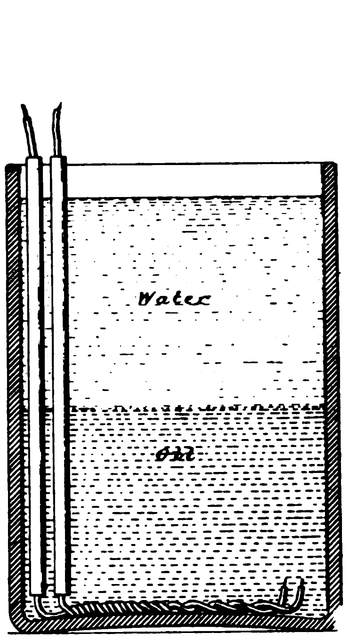

Figure 1.

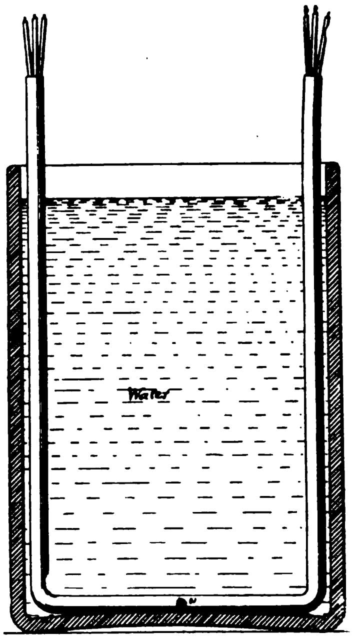

Figure 2.

Six years since there was a lead-covered cable insulated with oil, armored and laid across the Delaware river. The cable contained 50 conductors, not one of which has failed. The cost of this cable of 50 conductors was no more than that of an ordinary gutta-percha insulated cable of five conductors. The gutta-percha insulated cables across the Delaware during this period have been continually subject to mishaps. Many of the conductors have been injured by lightning, although protected by lightning arresters. When the gutta-percha insulation is punctured by atmospheric electricity, it leaves a hole in the insulation in which water enters, by which the current passes to earth. The cable has to be under-run, the leak found and the hole sealed up, but a hole cannot be made in a liquid. Many of the small streams flowing into the Delaware are bridged with draws to let through passing vessels. Beneath these draws have been placed lead cables, which in some instances have been caught and kinked, as shown in figure

Figure 3.

3. The strain upon these kinks has been such that if the wire had been insulated with gutta-percha or india-rubber the insulation would have been destroyed. The combination of lead, cotton, and the wire is much less liable to injury from a strain of this nature than the combination of india-rubber or gutta-percha with the wire as insulated in the usual form.

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COMBINED TABLE OF ALL THE PRINCIPAL WIRE GAUGES.

BY CARL HERING.

(Copyrighted by Carl Hering, 1886.)

THE following table contains in the order of their size, the diameters in mils and millimetres, and the cross-sectional area in square mils and square millimetres, of eleven of the most important wire-gauges used in this country and abroad. The first eight columns contain the numbers of the different gauges, whose names are given at the head of the columns. The ninth column contains a series of vulgar fractions of an inch. The tenth column, besides giving the diameters in mils of all the other different gauges, contains, in bold type, a regular series of values in mils, which might be termed a *scale of decimals of an inch*, a scale which is highly recommended by many, as avoiding the objectionable gauge numbers. The eleventh column, besides giving the sizes in millimetres of all the other different gauges, contains, in bold type, a regular series of values in millimetres and decimals, the scale which is used throughout Europe, except in England.

The last four columns may also be used as a table for converting millimetres into mils (or inches) or the reverse, for converting square mils into square millimetres, or the reverse; for converting areas in mils into areas in millimetres; for finding the areas in either square mils or square millimetres from diameters in mils or millimetres, or the reverse, etc. Numbers not found with the decimal point in the desired place, will, in many cases, be found with the decimal point in a different place, for instance if it is desired to know the cross section in square mils or millimetres of a wire 480. mils diameter, it may be found either under 480 or 48.0 or 4.8 mils.

By the use of this table many calculations are simplified, while many others are avoided. For instance, according to Thomson's rule of allowing 50 ampères per square centimetre cross section, the wire of any gauge may be found directly, for any current, from the last column.

American or B. & S.	New British, or Standard (March 1st, 1884).	Birmingham or Stubs (Holzapffel), or Old English Standard.	London.	Wynn (English).	Old English.	Another Birmingham (Sprague).	Jauge Carcasse (French).	Vulgar fractions of an inch.	Diameter. Mils. 1 inch = 1,000 mils.	Diameter. Millimetres. 1 mm. = 39.3708 mils.	Cross Section. Square mils. 1 sq. inch = 1,000,000 sq. mils.	Cross Section. Square millimetres. 1 sq. mm. = 1550.1 sq. mils.
I.	II.	III.	IV.	V.	VI.	VII.	VIII	IX.	X.	XI.	XII.	XIII.
								1	**1000.0**	25.400	785398.	506.69
								$\frac{3}{4}$	**750.0**	19.050	441786.	285.01
								$\frac{5}{8}$	**625.0**	15.875	306796.	197.93
	0000000							$\frac{1}{2}$	**500.0**	12.700	196350.	126.68
	000000								464.	11.785	169093.	109.09
0000									460.00	11.684	166190.	107.22
		0000	0000						454.	11.53	161883.	104.44
									450.0	11.430	159043.	102.605
								$\frac{7}{16}$	437.5	11.113	150330.	96.984
	00000								432.	10.972	146574.	94.56
		000	000						**425.0**	10.80	141863.	91.61
000									409.64	10.4047	131790.	85.026
	0000								**400.0**	10.160	125664.	81.070
									393.7	**10.000**	121740.	78.54
		00	00						380.	9.652	113411.	73.165
				000				$\frac{3}{8}$	**375.0**	9.525	110450.	74.25
									374.0	**9.500**	109858.	70.88
	000								372.	9.448	108687.	70.12
00									364.80	9.2657	104518.	67.428
									354.3	**9.000**	98588.	63.62
				00					**350.0**	8.890	96211.	62.07
	00								348.	8.839	95115.	61.37
								$\frac{11}{32}$	343.75	8.731	92810.	59.872
		0	0						**340.**	8.636	90792.	58.573
									334.7	**8.500**	87958.	56.75
				0					**325.0**	8.255	82958.	53.52
0									324.86	8.2513	82887.	53.473
	0								824.	8.229	82448.	53.19
									315.0	**8.000**	77916.	50.27
								$\frac{5}{16}$	312.5	7.937	76699.	49.48
				1					308.	7.696	72107.	46.52
	1	1	1						**300.0**	7.620	70686.	45.60
									295.3	**7.500**	68479.	44.18
1									289.30	7.3480	65732.	42.406
		2	2						284.	7.213	63347.	40.87
								$\frac{9}{32}$	281.25	7.144	62130.	40.080
				2					280.	7.112	61575.	39.724
	2								276.	7.010	59828.	38.59
									275.6	**7.000**	59653.	38.48
									275.0	6.985	59390.	38.32
		3	3						259.	6.578	52685.	33.99
				3					258.	6.553	52279.	33.73
2									257.63	6.5436	52128.	33.630
									255.9	**6.500**	51436.	33.18
	3								252.	6.401	49876.	32.168
								$\frac{1}{4}$	**250.0**	6.350	49087.	31.67
		4	4	4					238.	6.045	44488.	28.70
									236.2	**6.000**	43827.	28.27
								$\frac{15}{64}$	234.38	5.952	43143.	27.834
	4								232.	5.893	42273.	27.272
3									229.42	5.8272	41339.	26.669
									225.0	5.715	39761.	25.651
		5	5						220.	5.588	38013.	24.524
								$\frac{7}{32}$	218.75	5.556	37580.	24.246
				5					218.	5.537	37325.	24.08
									216.5	**5.500**	36827.	23.76
	5								212.	5.385	35299.	22.77
4									204.31	5.1893	32784.	21.150
								$\frac{13}{64}$	203.13	5.159	32405.	20.905
		6	6						203.	5.156	32365.	20.88
				6		6			**200.0**	5.080	31416.	20.27
									196.9	**5.000**	30435.	19.63
									192.9	**4.900**	29230.	18.86
	6								192.	4.877	28953.	18.68
									190.0	4.826	28350.	18.32
									189.0	**4.800**	28055.	18.10
								$\frac{3}{16}$	187.5	4.762	27610.	17.81
									185.0	**4.700**	26880.	17.35
				7					182.	4.623	26016.	16.78
5									181.94	4.6212	25999.	16.773
									181.1	**4.600**	25760.	16.62
		7	7						**180.0**	4.572	25447.	16.417
									177.2	**4.500**	24647.	15.90
	7								176.	4.470	24328.	15.69
									175.	4.445	24053.	15.52
									173.2	**4.400**	23569.	15.21
								$\frac{11}{64}$	171.88	4.366	23203.	14.968
						8			**170.0**	4.318	22698.	14.643
									169.3	**4.300**	22510.	14.52
									165.4	**4.200**	21475.	13.85
		8	8	8					165.	4.191	21382.	13.79
6									162.02	4.1153	20618.	13.301
									161.4	**4.100**	20464.	13.20
	8								**160.0**	4.064	20106.	12.971
									157.5	**4.000**	19479.	12.566
								$\frac{5}{32}$	156.25	3.969	19170.	12.370
						9			155.	3.937	18869.	12.173
									153.5	**3.900**	18517.	11.946
									150.0	3.810	17671.	11.401
									149.6	**3.800**	17579.	11.341
				9					149.	3.785	17437.	11.250
		9	9						148.	3.759	17203.	11.099
									145.7	**3.700**	16666.	10.752
7									144.29	3.6648	16351.	10.5484
	9								144.	3.658	16286.	10.508
									141.7	**3.600**	15778.	10.179
								$\frac{9}{64}$	140.63	3.572	15532.	10.020
						10			**140.0**	3.556	15394.	9.931
									137.8	**3.500**	14913.	9.621
		10	10	10					134.	3.403	14103.	9.0981
									133.9	**3.400**	14073.	9.079
									130.0	3.302	13273.	8.563
									129.9	**3.300**	13258.	8.553
8									128.49	3.2636	12967.	8.3653
	10								128.	3.251	12868.	8.302
									126.0	**3.200**	12466.	8.042
								$\frac{1}{8}$	125.	3.175	12270.	7.917
									122.1	**3.100**	11699.	7.548
		11	11	11		11			**120.0**	3.048	11310.	7.2963
									118.1	**3.000**	10954.	7.069
	11								116.	2.946	10568.	6.818
9									114.42	2.9063	10283.0	6.6339
									114.1	**2.900**	10238.	6.605
									110.2	**2.800**	9544.5	6.158
						12			**110.0**	2.794	9503.	6.087
								$\frac{7}{64}$	109.38	2.778	9395.	6.061
		12	12						109.	2.769	9331.	6.020
				12					107.	2.718	8992.	5.801
									106.3	**2.700**	8874.9	5.726
	12								104.	2.642	8495.	5.480

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American or B. & S.	New British, or Standard (March 1st, 1884).	Birmingham or Stubs (Holzapffel), or Old English Standard.	London.	Wynn (English).	Old English.	Another Birmingham (Sprague).	Jauge Carcasse (French).	Vulgar fractions of an inch.	Diameter. Mils. 1 inch = 1,000 mils.	Diameter. Millimetres. 1 mm. = 39.3708 mils.	Cross Section. Square mils. 1 sq. inch = 1,000,000 sq. mils.	Cross Section. Square millimetres. 1 sq. mm. = 1550.1 sq. mils.
I.	II.	III.	IV.	V.	VI.	VII.	VIII	IX.	X.	XI.	XII.	XIII.
									102.4	**2.600**	8229.7	5.309
10									101.897	2.5881	8154.8	5.2610
									100.0	2.540	7854.	5.067
									98.43	**2.500**	7608.8	4.909
		13	13	13		13			**95.0**	2.413	7088.	4.5729
									94.49	**2.400**	7012.4	4.524
								$\frac{3}{32}$	93.75	2.381	6902.5	4.453
	13								92.	2.337	6648.	4.289
11									90.742	2.3048	6467.0	4.1721
									90.55	**2.300**	6440.	4.155
									90.0	2.286	6362.	4.1042
									86.62	**2.200**	5892.	3.801
						14			**85.0**	2.160	5675.	3.664
				14					84.	2.134	5542.	3.5752
		14	14						83.	2.108	5411.	3.491
									82.68	**2.100**	5369.	3.464
12									80.808	2.0525	5128.6	3.3087
	14								**80.0**	2.032	5027.	3.2428
									78.74	**2.000**	4869.8	3.142
								$\frac{5}{64}$	78.125	1.985	4792.5	3.093
						15			**75.0**	1.9050	4417.9	2.850
									74.81	**1.900**	4395.	2.835
				15					73.	1.854	4185.	2.700
	15	15	15						72.	1.829	4072.	2.627
13									71.962	1.8278	4067.2	2.6239
									70.87	**1.800**	3943.52	2.545
									70.0	1.7780	3848.	2.483
									66.93	**1.700**	3518.3	2.270
		16	16	16		16			**65.0**	1.651	3318.	2.141
14									64.084	1.6277	3225.4	2.0808
	16								64.	1.626	3217.	2.0755
									62.99	**1.600**	3114.5	2.011
								$\frac{1}{16}$	62.5	1.5875	3068.	1.9793
									60.0	1.5240	2827.	1.8241
									59.06	**1.500**	2739.	1.767
		17	17	17					58.	1.473	2642.	1.705
15					17				57.068	1.4495	2557.9	1.6502
						17			57.	1.446	2552.	1.646
	17								56.	1.422	2463.	1.5890
									55.12	**1.400**	2384.	1.539
									55.0	1.397	2375.6	1.583
									51.18	**1.300**	2057.4	1.327
16					18				50.821	1.2908	2028.5	1.3086
				18		18			**50.0**	1.2700	1963.5	1.267
		18	18						49.	1.245	1886.	1.217
	18								48.	1.219	1810.	1.1674
									47.25	**1.200**	1753.1	1.1310
								$\frac{3}{64}$	46.875	1.191	1725.6	1.113
17					18½				45.257	1.1495	1608.7	1.03780
						19			**45.0**	1.143	1590.	1.0261
									43.31	**1.100**	1473.1	.9509
				19					43.	1.092	1452.	.9869
		19							42.	1.067	1385.	.89380
18					19				40.303	1.02367	1275.7	.82302
	19		19			20			**40.0**	1.016	1257.	.81070
									39.37	**1.000**	1217.4	.7854
				20					37.	.9398	1075.2	.6937
	20								36.	.9144	1017.9	.6567
19					20				35.891	.91160	1011.69	.65268
									85.43	**.900**	985.88	.6362
		20	20			21			**35.0**	.8890	962.1	.6207
	21	21		21		22			32.	.8128	804.2	.5188
20					21				31.961	.81181	802.31	.51760
			21						31.50	**.800**	779.3	.5027
								$\frac{1}{32}$	31.25	.7937	766.99	.4948
									30.0	.7620	706.9	.4560
			22						29.5	.7493	683.5	.4409
				22					**29.0**	.7366	660.5	.4261
21					22				28.462	.72293	636 26	.41048
	22	22				23			**28.0**	.7112	615.8	.39724
									27.56	**.700**	596.53	.3848
			23						**27.0**	.6858	572.5	.3694
				23					**26.0**	.6604	530.9	.84252
22					24				25.347	.64379	504.58	.32552
		23	24			24			**25.0**	.6350	490.9	.3167
	23								**24.0**	.6096	452.4	.29185
									23.62	**.600**	438.27	.2827
			25	24		25			**23.0**	.5842	415.5	.2679
23					25				22.572	.57381	400.15	.25815
	24	24							**22.0**	.5588	380.1	.24524
				25					**21.0**	.533	346.4	.2231
			26						20.5	.5207	330.06	.2129
24					26				20.101	.51055	317.33	.20472
	25	25							**20.0**	.5080	314.2	.2027
							P		19.69	**.500**	304.35	.1963
						26			**19.0**	.4826	283.5	.1832
			27						18.75	.4762	276.10	.1781
				26			12		18.50	.470	268.8	.1735
	26	26				27			**18.0**	.4572	254.5	.16417
25					27				17.900	.45466	251.66	.16235

American or B. & S.	New British, or Standard (March 1st, 1884).	Birmingham or Stubs (Holzapffel), or Old English Standard.	London.	Wynn (English).	Old English.	Another Birmingham (Sprague).	Jauge Carcasse (French).	Vulgar fractions of an inch.	Diameter. Mils. 1 inch = 1,000 mils.	Diameter. Millimetres. 1 mm. = 39.3708 mils.	Cross Section. Square mils. 1 sq. inch = 1,000,000 sq. mils.	Cross Section. Square millimetres. 1 sq. mm. = 1550.1 sq. mils.
I.	II.	III.	IV.	V.	VI.	VII.	VIII	IX.	X.	XI.	XII.	XIII.
							14		17.32	.440	235.69	.1521
									17.0	.4318	226.98	.1464
			28						16.5	.4191	213.82	.1379
	27								16.4	.4166	211.2	.1363
		27		27		28			**16.0**	.4064	201.1	.12971
26					29			$\frac{1}{64}$	15.941	.40488	199.57	.12875
							16		15.75	**.4000**	194.79	.12566
									15.625	.3969	191.75	.1237
			29						15.5	.3937	188.7	.1217
						29			**15.0**	.3810	176.7	.1140
	28								14.8	.3759	172.0	.1110
							18		14.57	**.3700**	166.7	.1075
27					30				14.196	.36056	158.27	10211
		28		28		30			**14.0**	.3556	153.9	.09931
			30						13.75	.3492	148.5	.09580
	29								13.6	.3454	145.3	.09372
							20		13.39	**.3400**	140.7	.09079
		29		29		31			**13.0**	.3302	132.7	.08563
28					31				12.641	.32109	125.51	.08097
							22		12.60	**.3200**	124.7	.08042
	30								12.4	.3150	120.8	.07793
			31						12.25	.3111	117.9	.07604
		30		30					**12.0**	.3048	113.1	.07296
									11.81	**.3000**	109.54	.07069
	31								11.6	.2946	105.68	.06818
							24		11.41	**.2900**	102.39	.06605
29					32				11.258	.28594	99.535	.06421
			32						11.25	.2857	99.40	.06413
				31					**11.0**	.2794	95.03	.06087
	32								10.8	.2743	91.61	.05910
			33						10.25	.2604	82.516	.05323
							26		10.24	**.2600**	82.297	.05309
30					33				10.0252	.25463	78.935	05092
	33	31		32		32			**10.00**	.2540	78.54	05067
						34			9.6	.244	72.38	.04676
			34						9.5	.2413	70.88	.04573
	34								9.2	.2337	66.48	.04289
		32	35						**9.0**	.2286	63.62	.04104
31					34				8.9277	.22676	62.599	.04039
						35			8.7	.221	59.45	.03836
							28		8.66	**.220**	58.90	.03801
	35								8.4	.2134	55.42	.03575
		33							**8.0**	.2032	50.27	.03243
32					35				7.9503	.20193	49.643	.03203
				36		36			7.9	.201	49.02	.03173
							30		7.874	**.200**	48.70	.03142
	36								7.6	.1930	45.36	.02926
			36						7.5	.1905	44.18	.02850
33					36				7.0800	.17983	39.369	.02539
		34							**7.0**	.1778	38.48	.02483
	37								6.8	.1727	36.32	.02343
						37			6.7	.1702	35.26	.02275
							32		6.69	**.170**	35.15	.02270
			37						6.5	.1651	33.18	.02141
34					37				6.3049	.16014	31.221	.02014
	38								**6.0**	.1524	28.27	.01824
						38			5.8	.1473	26.42	.01705
			38						5.75	.1460	25.97	.01678
35					38				5.6147	.14261	24.759	.01597
							34		5.51	**.140**	23.84	.01539
	39								5.2	.1321	21.24	.01370
36		35	39		39				**5.0000**	.12700	19.635	.01267
	40								4.8	.1219	18.10	.01167
							36		4.725	**.120**	17.531	.01131
			40						4.5	.11430	15.904	.01026
37					40				4.4526	.11309	15.571	.010046
	41								4.4	.1117	15.21	.009809
							38		4.33	**.110**	14.73	.009503
						39			4.2	.1067	13.85	.008938
	42	36							**4.0**	.1016	12.57	.008107
38					41				3.9652	.10071	12.349	.007967
							40		3.937	**.100**	12.174	.007854
						40			3.9	.0992	11.95	.007729
	43								3.6	.0914	10.179	.006561
							42		3.543	**.090**	9.8588	.006362
39									3.5311	.08969	9.7928	.006318
						41			3.3	.0839	8.553	.005529
	44								3.2	.0813	8.042	.005191
							44		3.150	**.080**	7.793	.005027
40									3.1445	.07987	7.7661	.005010
									3 0	.0762	7.069	.004560
	45								2.8	.0711	6.158	.003972
							46		2.756	**.070**	5.965	.003848
	46								2.4	.0610	4.524	.002918
							48		2.362	**.060**	4.3827	.002827
	47								**2.0**	.0508	3.142	.002027
							50		1.969	**.050**	3.0435	.001963
	48								1.6	.0406	2.011	.001297
	49								1.2	.0305	1.1310	.000730
	50								**1.0**	.0254	.7854	.000507

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THE SILVER VOLTAMETER.

BY GEORGE L. ANDERSON.

ONE of the simplest and most accurate methods of determining, or verifying, the constant of a current, or a potential galvanometer, is that by the silver voltameter. A bowl, usually of platinum, of 1, 2 or 3 inches diameter, according to the strength of current, contains the electrolyte and serves as the cathode. The anode by which the current enters is in the form of a disc one-eighth inch thick, or spiral of wire, No. 12, of chemically pure silver. The suspending wire passes through a binding post above, so that the anode may be lowered to the middle of the bowl whenever desired. It must not approach the sides too closely. To protect the deposit from disintegrated silver from the anode, the latter is wrapt with filter paper secured by a little white thread. In position the platinum basin rests on a ring of strong silver wire, by which the current leaves the voltameter. It enters by the binding post.

The electrolyte is usually a neutral 15 to 30 per cent. solution of pure silver nitrate which, in a 3-inch bowl, will admit of the nominal action of one ampère for one hour. For currents not exceeding one-fourth ampère considerable latitude may be allowed in the strength of solution, say 4 per cent. If the solution is too weak the deposit tends to become loose and irregular. Currents not exceeding $1\frac{1}{2}$ ampères can be accurately measured by using a 30 per cent. solution in a 3-inch bowl and stopping the operation at the end of 20 minutes. Still an accuracy of one-tenth of 1 per cent. is attainable from the deposit from a 40 or 50 per cent. solution in a 3′ diameter bowl by a 4 ampère current flowing from 10 to 15 minutes. When the current is too strong or the operation is continued for too long a period, the deposit, which should be constantly watched, begins to deteriorate.[1] Platinum crucibles are somewhat expensive, and seldom exceed 3 inches in diameter. For heavier currents two or more voltameters of the same or different sizes may be arranged in parallel without sensible error. Silver chlorate may be used instead of the nitrate, but to neither ought the acetate, or potassium cyanide, to be added to facilitate deposition.

A little care is necessary in cleaning the platinum crucible and in weighing it before and after the deposit. A trace of organic matter or any foreign particles on the inner surface will interfere with the deposit, and render the calibration worthless. It is safer not to touch the bowl with the hands. While being cleaned it may be held with soft, plain paper and while being heated by platinum-pointed nippers. Only distilled water and chemically pure nitric acid are used.

The silver deposit is removed by pouring in a little nitric acid which dissolves it in two or three minutes. The solution and all other washings containing silver are preserved and sold to the trade. Wash the basin with distilled water, again pour in a little nitric acid and then rinse repeatedly with water until nitric acid is removed. After the inner surface, proceed with the outer. If any portion of the surface, within or without, does not become clear with this treatment, rub with pumice and rinse with alcohol or hot water. After washing, the bowl is allowed to drip and then dried over a spirit lamp, a gas flame, or placed in a drying chest at 160° for five minutes. It is subsequently weighed.

If the instrument to be calibrated is such that the current will give a readable deflection, the circuit will be a simple one—the battery, galvanometer, reversing key, voltameter, and a resistance for regulating the current, if necessary. Several calibrations may be necessary for different portions of the arc swept by the needle. If the reversing key opens the circuit, allowance is made for the time—sometimes one-tenth of a second—during which the current is interrupted. For determining the constant of a reflecting current galvanometer the main circuit will comprise a battery, voltameter, a two-point switch and a "no-resistance" shunt. The latter consists of two or three or more parallel german-silver strips—each, for example, two feet long and four inches wide—terminating in heavy copper blocks to which they are hard-soldered and clamped; it stands in a wooden box filled with a high-grade coal oil, and its resistance is practically zero. From the copper blocks a branch circuit sets out containing the current, galvanometer, a mercury reversing key, and a carefully adjusted resistance box. The arrangement is the same for a mirror potential galvanometer, except that the "no-resistance" shunt is replaced by a shunt of 20 or 30 ohms of bare german-silver wire wound on a glass frame and submerged in kerosene or turpentine. Its resistance is, for a known temperature, accurately determined. Either galvanometer is set up beyond the influence of the main current, and its resistance as well as that of its leads (*i. e.* the branch) are ascertained. The two-point switch may be simply a bent wire of the main circuit dipping into one of two mercury cups. One cup leads *to* the voltameter, the other *past* it. With a watch or chronometer at hand whose rate is known, the voltameter can be switched into or out of the circuit on an even minute so closely that the error for a period of half an hour will not exceed $\frac{1}{1000}$. For a shorter period the percentage error will be, of course, greater.

In order to calibrate, for example, the current galvanometer, the platinum bowl having been cleaned and dried as described, is, after cooling, carefully weighed to $\frac{1}{10}$ milligram in an analytical balance, then placed in its position on the ring and filled with the nitrate solution into which the anode is lowered, just so that it may everywhere be as nearly as possible equally distant from the sides of the basin. All being in readiness, the operator at the two-point switch breaks the circuit of the battery and "no-resistance" shunt, now warmed, and by means of a chronometer switches the voltameter into the circuit on an even minute. As soon as the galvanometer needle comes to rest a reading is taken, the current in the branch is reversed, the reading noted down, and so on thereafter at regular intervals of say one minute. The scale is closely watched, and any unusual fluctuations recorded. There should be a thermometer in the liquid surrounding the shunt, one in the resistance box, and one suspended near the galvanometer. If the current shows a decided fall or rise, the operation may as well be discontinued; but if the current remains steady, let the deposit continue for 15, 20 or 30 minutes, when the main circuit is broken again on an even minute, the anode is raised, the solution is poured back into the bottle, and the bowl removed to the trough with the platinum nippers and well rinsed. In order to remove all salt from the pores of the deposit, it is then set to soak for an hour or two, or preferably over night, when it is again repeatedly rinsed and dried over a flame or in an air closet. At a red heat silver and platinum begin to alloy, so that the bowl containing a deposit must not be heated to redness. It is then weighed to $\frac{1}{10}$ mgm., and if the weight of the basin without deposit be subtracted, the result will be the weight of the deposit due to the current.

According to Lord Rayleigh and Professor Kohlrausch, to whom we are indebted for the most trustworthy data regarding the silver voltameter, the quantity of silver deposited from a solution in one hour by one ampère is 4.0246 grams. Since the amount of deposit varies directly as the strength of current and the time, we have the means at hand of readily determining at any time in absolute units the strength of current, and, therefore, the values of the divisions of the scale of a galvanometer placed in the circuit.

The following calibration of a current galvanometer by means of a silver voltameter was made June 5th. There were

1. Ordinary differences of temperature have no effect on the amount of deposit. The amount of deposit in a bowl at 50° C. over one at 4° C. for the same current will not exceed $\frac{1}{1000}$.

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four secondary cells, the voltameter, two-point switch, and the "no-resistance" shunt, in the main circuit and in the branch from the shunt, the galvanometer of .4 ohm resistance at 25° C., a resistance box adjusted to Paris ohms at 25° C., with the 10-ohm coil unplugged, and a reversing key of four mercury cups. The basin was three inches in diameter, and the solution had 45 per cent. strength. The chronometer's rate was sufficiently small to be neglected. There were in use three thermometers graded to tenths of a degree C. C' represents the strength of current as given by the deposit, and K the constant of the galvanometer at 25° C.

4:30 P.M., June 5. J. SMITH.

Weight of platinum basin before deposit = 72.02291 grams.
" " after " = 75.71056 "
Weight of deposit (13 minutes), = 3.68765 "

$$C' = \frac{3.68765}{.067076} \times \frac{1}{13} = 4.2295 \text{ ampères.}$$

GALVANOMETER READINGS.

Right.	Left.	Difference (2d).	Remarks.
21.05	37.66	16.61	Time = 13 mins.
.07	.64	.57	
.08	.63	.55	Res. = 10 ohm.
.08	.62	.54	
.09	.63	.54	Temp. Galv. = 28°.5 C.
.09	.63	.54	
.08	.61	.53	" Box = 27° .5 C.
.08	.63	.53	
.08	.61	.53	" Shunt = 27° .1 C.
.09	.60	.51	
.10	.60	.50	Deposit even and moder-
.10	.59	.49	
.11	.59	.48	ately close.
Mean (2d) = 16.532 divisions.			

$$K = \frac{4.2295 \times 1.00084}{16.532 \times 10.01 + .4026} = .02553$$

in which 1.00084 = correction of german-silver shunt for temperature = 1+.0004×2.1; 10.01 = coil resistance corrected for temp. = 10 (1 + .0038 × 2.5); .4026 = galv. res. cor. for temp. = .4 (1 + .0004 × 3.5.)

In many laboratories, and often for commercial purposes, the copper voltameter is used. It may still be required for very heavy currents, or in an emergency. But the copper plate oxidizes when heated in air, and changes weight in contact with the copper solution, so that the results obtained by its use are liable to be more than one per cent. in error.

DYNAMIC ELECTRICITY.

BY CARL HERING.

(Continued from page 146.)

CHAPTER II.

Fundamental Principles of Dynamos and Motors.

The explanations which are given in many text-books of the process of generating electric currents in the dynamo machine, and the production of mechanical power in the electric motor, by means of the electric current, are in many cases unsatisfactory. This is largely due to the failure of the authors to lay down any fundamental principle, applicable alike to all kinds of machines. The principles involved are often explained in an indirect and circuitous way, and in one well-known work recently published, the explanation of the manner in which the currents are generated in a Gramme ring armature are not merely misleading but absolutely erroneous, and are in fact inconsistent with actual results which may be obtained even from a rough test.

In attempting an explanation of the principle of the dynamo, we propose therefore, to discard insufficient and erroneous theories, and to take for our starting point the fundamental law illustrated in the action between a magnet and a current, as conclusively demonstrated by one of the most simple of experiments. By so doing it will be found that the generation of currents and of power in dynamos and motors may be explained by simple and direct methods, while at the same time the general directions which should be pursued to obtain the most economical proportions are pointed out.

In the year 1819, Hans Christian Oersted, a Danish philosopher, discovered that a current of electricity when caused to pass near a magnetic needle will deflect it. Or, in other words, he discovered that an electric current and a magnet exert a mutual force upon each other. This simple experiment is a demonstration of the fundamental principle of all dynamos and motors; by its means the generation of currents or power in all the different types of machines may be rendered easily intelligible without the intervention of abstruse or complicated theories, which in many cases have to be in themselves varied to correspond with the facts observed in various types of machines.

All electric motors are nothing more than direct applications of this principle on a large scale, for whatever is true of a small magnetic needle and a weak current, is equally true, in principle, of a large magnet and a powerful current. Every motor will be found upon analysis to consist of one or more magnets and a conductor traversed by a current of electricity, one of the two, or both, being capable of receiving a continued motion from the mutual force exerted between the magnet and the current, as shown in Oersted's experiment. The movable conductor may be in the form of one or more straight wires, or it may be a coil, or, as in a unipolar motor, a disc or hollow cylinder. In each of these modifications the operative principle remains the same, that is, simply the mutual action between the magnet and the current.

In electric motors this principle applies directly, as these are merely practical devices for carrying out Oersted's experiment on a large scale under such mechanical conditions as to obtain constant rotary motion. In the case of dynamos, however, a deduction from this principle applies, for while in motors the exact conditions of Oersted's experiment exist, in generators the magnet and the mechanical force are given, the resulting current being that which is required. The explanation of the action of generators, however, offers no additional difficulties, as the converse of Oersted's experiment is also true, namely, that if the conditions of that experiment be reversed, by moving the conductor in the reverse direction, a current will tend to be generated in that conductor, or, as it is generally stated, a current will be *induced* in that conductor, which is then termed the *inductor.* This is commonly known as one of Lenz's laws, which, stated in more precise terms, is this: *If a conductor be moved near a magnet it tends to generate a current, which will flow in the opposite direction to the current which would, by its action on the magnet, produce that motion.*

This may be further illustrated by analogy. Between the earth and a body held at some distance from it, there exists a force, which if allowed to act, will draw the body to the earth. Now if this is reversed by overcoming the force and lifting the weight, the amount of energy which was used in lifting it will again be stored up in the weight. Or, in other words, if the process of the falling weight is reversed, the same energy which was set free in falling will be generated again in the body. Similarly if Oersted's experiment, or the electric motor, be reversed by moving the conductor near the magnet in the opposite direction, the same amount of current will be generated that would have been necessary to produce this motion. As in the case of the weight, in which the energy developed in falling is equal to that required to raise it, so in electric induction, the current generated by moving the wire is theoretically equal to that which is required to produce that motion. For instance, if a certain amount of electri-

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cal energy in a movable conductor exerts a force or tendency to move in a certain direction, equal to one pound, on a large magnet, then it would require a force of one pound to generate that same amount of electrical energy in that conductor by moving it in the opposite direction.

These are the fundamental principles underlying the construction of all dynamos and motors, and by means of which the action in all of them may be explained, be they constant current, alternating current, unipolar, bi-polar or multi-polar. They all consist of a magnet and a conductor for the current, one or the other, or both of which are movable, as in Oersted's experiment.

In the explanation, just given, it was said that a *current* is generated by moving a wire in the vicinity of a magnet. It must be remembered, however, as pointed out in the first chapter, that a current is merely the result of the equalization of a difference of electrical pressure. Strictly speaking, therefore, it is not actually current but *electromotive force* or electrical pressure, which is generated by the induction in the moving wire, for by disconnecting or opening the circuit, it will be found that the electromotive force still exists, even if no current can flow. The word *current* was used merely for the sake of avoiding a multiplicity of terms in the explanation. A current does exist in most cases, but its existence is due only indirectly to induction. Its actual origin is due to an equalization of the electromotive force which has been generated by induction. As pointed out in the first chapter, it is quite similar to the case of a centrifugal air-blower, in which the *pressure* is that which is generated, the current being only a secondary result of this pressure. This conception of induction will be found to materially simplify the conception and solution of many problems which are met with in practice, as, for instance, the determination of the most advantageous mode of insulating the iron of armatures to avoid Foucault currents, in which case it is the current which must be avoided, not the generation of the difference of potential, for that cannot possibly be avoided except by an absence of all material, or by keeping the iron fixed in one position.

With a magnetic field of known strength, and with a given speed and direction of motion of the inductor, a certain definite electromotive force is developed, which may be theoretically calculated. But it is evident that with this electromotive force any desired current may be generated, according to the resistance of the circuit through which this electrical pressure equalizes itself, showing that the current is directly dependent only on the electromotive force and resistance, and not on the magnet nor the speed.

(*To be continued.*)

PRACTICAL APPLICATION OF TELPHERAGE.[1]

Telpherage has been defined as the transmission of goods and passengers by means of electricity without driver, guard, signalmen, or attendants. The conception of propelling electrically a continuous stream of light trains along an elevated *single* rail or rope was due to the late Prof. Fleeming Jenkin, but, as stated by him in his introductory address at the University of Edinburgh, he did not see his way to carry this conception into practice until he read the account of the electrical railway exhibited by Professors Ayrton and Perry at the Royal Institution in 1882, when the idea of subdividing the rubbed conductor into sections and providing an *absolute block* for automatically preventing electric trains running into one another was first publicly described. A combination between these three gentlemen was then effected, which led ultimately to the formation of the telpherage company and to the series of experiments, lasting for over two years, on actual telpher lines erected at Weston in Hertfordshire, on the estate of Mr. Pryor, the chairman of the company. Various devices were worked out forming the subject of patents, which, together with the other patents of Professors Fleeming Jenkin, Ayrton, and Perry in telpherage, previously taken out, are possessed by the present telpherage company. At the commencement of last year matters had sufficiently advanced for the erection of the commercial telpher lines, and as a tramway or road would have much interfered with the grazing and hay growing carried on in the fields at Glynde, and, as in addition these fields are under water during the winter, telpherage appeared to furnish the cheapest and most suitable mode of carrying the clay from the clay pits to the London, Brighton, and South Coast railway. Consequently the Sussex Portland Cement Co. decided to adopt this method of transport.

The line now opened is nearly a mile long, and composed of a double set of steel rods each 66 feet long, three-quarters of an inch in diameter, and 8 feet apart, supported on wooden posts standing about 18 feet above the ground, as seen in our illustration, figure 1, which is from a photograph taken of the line just before it crosses the stream.

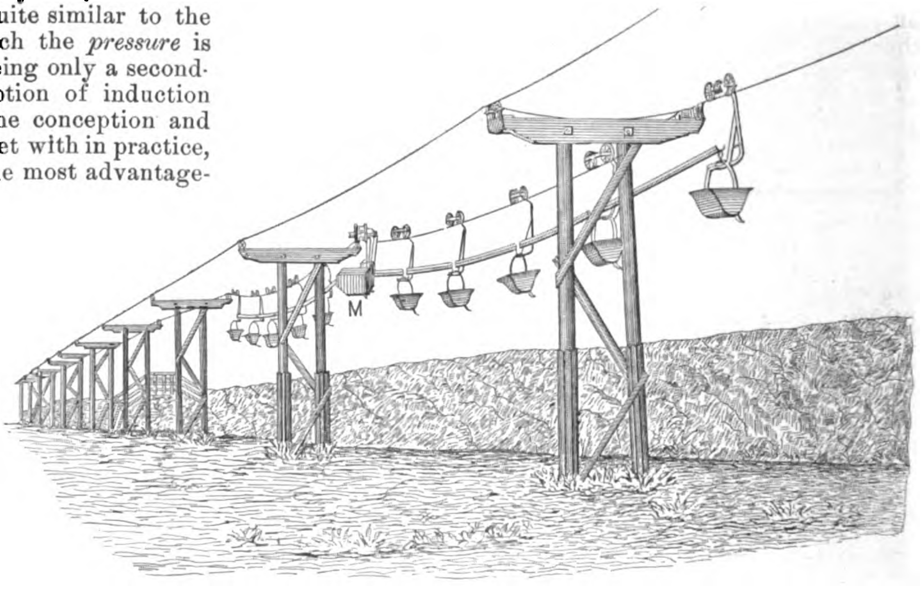

Figure 1.

On the death of the late lamented Prof. Jenkin the construction of the Glynde telpher line was left for completion in the hands of Prof. Perry, who was then appointed the engineer to the company. The new line, it must be understood, is more than a mere experimental attempt. Although, as scientific men will appreciate, a new undertaking must necessarily involve much tentative experience, the programme carried out at the opening marked the final result of the experiences gained by the constructors under the direction of Prof. Perry, and the company are now regularly delivering clay at the Glynde railway station for the use of the Newhaven Cement Co. at a price, as we are informed, of $7\frac{1}{2}d.$ per ton.

The garlanded train which passed along the steel rodway consisted of an electric locomotive, as may be seen in figure 1, at about the middle of the train and propelled by the electromotor M, and 10 skeps, or buckets, which hang by their traveling wheels from the steel line. Each skep weighs 101 lbs., and carries 250 to 300 lbs. of dry clay, and, by distributing these evenly and somewhat widely apart, the strain on the steel line is small although

1. *Nature* (London).

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the total weight of the train and clay is about two tons; also, as equal weights are simultaneously ascending and descending similar inclines on the several spans the effect of the sag on the mechanical resistance of the train is neutralized, and little more resistance is experienced than in hauling a similar train along a rigid road. The rate of traveling is 4 to 5 miles an hour, about two electric horse-power only being necessary to be furnished at the engine house to propel the train at this speed, and the train is under the control of a workman, who, by touching a key, can start, stop or reverse the train at pleasure. On the arrival of each telpher train at the railway siding the clay is emptied into the railway wagons by the skeps being tipped over, this being effected either by a man touching with a pole the handles which are seen in figure 1 hanging down from the skeps, or automatically by these handles coming successively into contact with a wooden arm padded with india-rubber which is made to stand out from the post where it is desired the clay is to be emptied. One train will deliver the minimum amount of clay (150 tons per week) required by the Cement company, but, if necessary, twenty trains can be run on the line without fear of a collision as an absolute automatic block is provided, and the trains are, moreover, governed automatically so as to run up or down an incline at the same speed.

This automatic governing of the speed of the train is effected in two ways—first, there is a governor attached to each motor, which interrupts the electric circuit, and cuts off the power, when the speed becomes too high; secondly there is a brake which is brought into action should the speed attain a still higher value. To avoid the formation of a permanent electric arc when the circuit is broken, the governor, figure 2, is so arranged that the diverging weights are in *unstable* equilibrium between two stops—they fly

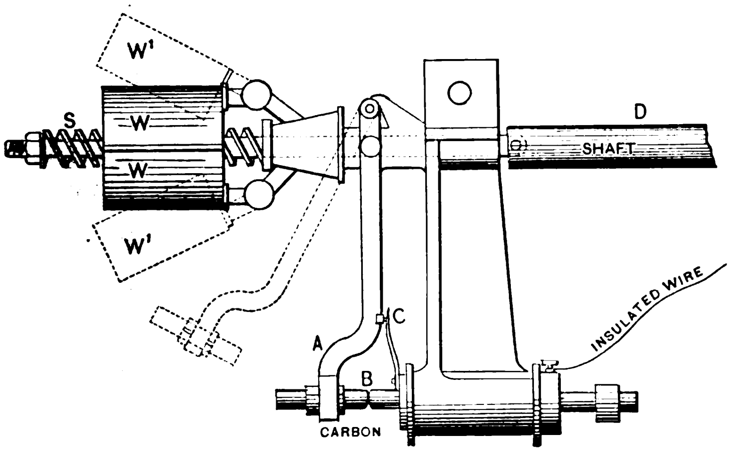

FIGURE 2.

out at about 1700 revolutions per minute of the motor, and fly back at about 1600. When the circuit is closed the current is conveyed across the metallic contact at C. When the weights W W fly out this contact is first broken, but no spark occurs because a connection of small resistance is continued at B between the piece of carbon and a piece of steel, which being pressed out by a spring follows the carbon for a short distance as the arm A begins to fly out. This contact is next broken, producing an electric arc, which, however, is instantly extinguished by the lever A flying out to the dotted position. The brake is shown in figure 3, and consists simply of a pair of weights, W W, which at a limiting speed greater than 1700 revolutions per minute of the motor press the brake blocks B B against the rim C C, and introduce the necessary amount of retarding friction. In practice, however, with the gradients such as exist at Glynde, and which do not exceed 1 in 13, the economic method of automatically cutting off the power with the governor is all that is necessary to control the speed of the train; the brake rarely coming into action. With steeper gradients, however, the brake would undoubtedly be very useful.

The current required is 8 ampères per train, this current

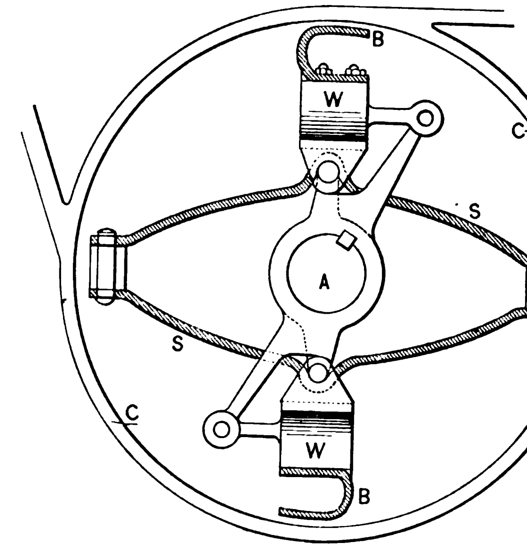

FIGURE 3.

being measured by an ammeter in the engine house, and by roughly timing the intervals when no current is being given to a train, that is, when the governor is acting, the particular hill the train is descending can be electrically determined by practice, and so the progress of a train along the telpher line can be approximately followed by simply watching the ammeter in the engine house. The electric current is supplied from a 200-volt dynamo driven by a steam engine, and controlled by a Willans electric governor which automatically varies the speed of the engine and dynamo so as always to keep the electromotive force at 200 volts whatever be the number of trains running; hence the starting or stopping of one telpher train in no way affects the speed of the remainder. It is obvious that water-power or any other source of power can be used where available, even when the source of power is at a considerable distance from the line. By means of compensating gear the tension of the line is so regulated that it can never exceed $2\frac{1}{4}$ tons on each rod, whatever the temperature, and for straining the steel rods, when first erected, up to the right tension an ingenious arrangement has been devised during the construction of the line of vibrating them and determining the strain on a rod from the number of vibrations it makes per minute.

The way in which a single wheel track is made to serve for one train, or rather two wheel tracks for two trains, instead of the necessity of having four wheel tracks for two trains, as in the ordinary electric railways, is seen

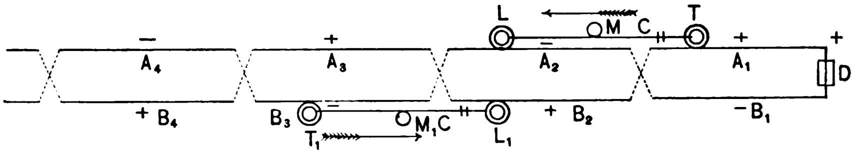

FIGURE 4.

from figure 4. D is the dynamo maintaining two long conductors permanently at different potentials, indicated by the signs + and — of each section. The wheels L and T of one train, and L_1 and T_1 of the other, are insulated from their trucks and joined by a conductor attached respectively to the terminals of the motor M and M_1. A current

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consequently is always passing from a + section to a — section through each motor. Mechanically then each train is supported by what is practically one continuous steel rod, but in reality at the tops of the posts the rods are electrically subdivided into sections and joined across by insulated wires, one of which may be seen at the top of the posts in figure 1. The wires connecting the two skeps with the motor, shown in figure 4, are not seen in figure 1, as they were too thin to appear in the photograph from which this figure was taken. To prevent the metallic wheels of the skeps short circuiting the two sections as they cross the tops of the posts, there are insulated gap pieces, which may be seen in figure 1, at the tops of the posts where the steel rod is electrically divided.

Various devices have been tried for gripping the rod to obtain the hold necessary to enable the locomotive to haul the train, and these, with many ingenious plans of *nest gearing* for economically communicating the power given out by the very quickly revolving electromotor to the much more slowly moving wheels of the telpher locomotive, formed the subject of Prof. Jenkin's lecture at the Society of Arts in the spring of 1884. Practically, however, it is found that for moderate inclines direct driving, with pitch chains, of two wheels with india-rubber treads gives a gravitation grip sufficiently large for satisfactory haulage; hence the expense of the locomotive, the complexity and wear and tear of its parts combined with the risk of its getting out of order have all been most materially reduced during the last twelve months.

As the result of the experience gained in the construction of the Glynde line, it is estimated that a similar line could now be erected at short notice for a total cost of £1200, including engine, dynamo, permanent way, and five trains, with locomotives to carry 100 tons daily; the working expenses, including coal, attendance, and depreciation, being less than 3*d.* per ton per mile upon the material carried. A double line like that at Glynde, ten miles long, worked heavily, would carry material at a cost of 2*d.* per ton per mile, the skeps being empty on their return journey. The larger part of the original cost of the telpher line is due to dynamos and rolling stock. This plant can be increased, as we are informed, in proportion to the work required, so that there is a very moderate increase of cost in the rate per ton per mile for a small traffic, as compared with a larger one. On the other hand, a line constructed for a small traffic will accommodate a much larger one with no fresh outlay on the line itself.

Leaving these facts and figures to speak for themselves, it now only remains to point out the advantages claimed for this system of electric carriage. In the first place the facility with which such a line can be run up and carried over uneven ground or across streams, high fences, and deep ditches, where an ordinary railway would involve serious expense, is sufficiently obvious. A telpher line need not, as a railway necessarily does, impede the ordinary agricultural operations, but may be carried over fields and pasture lands with little inconvenience. The telpher line is, moreover, in itself a source of power which can be simultaneously tapped at any desired points and made to assist in the work of agriculture, as the visitors at the opening had an opportunity of witnessing when, by means of a motor connected with the line, a turnip-cutter was put into operation. The possibility of utilizing natural sources of power like falling water, and of working the line at great distances from such sources will, as already stated, be evident to our readers. A special advantage claimed for the new system is the ease with which the trains can go round sharp curves without loss of power, since electricity, having no momentum, experiences no loss in going round a corner, whereas, with the overhead wire haulage system, as used in Spain and elsewhere, there is both considerable friction and great wear and tear of the running wire ropes where they go round sharp curves.

The constructors of the Glynde line are careful to point out that the present line is far from perfect; unnecessary gradients have been introduced in order to show how the system can be carried over uneven land, and many other improvements have suggested themselves in the course of their experience, of which advantage would be taken in future undertakings. In face of these disadvantages, the success which marked the opening proceedings renders telpherage, as a system, a very hopeful and cheap method of transference, and the company is to be congratulated in having taken the first initiative step in this new application of electricity. That telpherage will ever come into serious competition with the large railways is not intended, for the statement made by the company is to the effect that the function of the telpher line is not to compete with railways, but to do cheaply the work of horses and carts, light tramways, and the wire rope haulage system, and this, we think, it has a good chance of successfully accomplishing.

ABSTRACTS AND EXTRACTS.

COTTON MILLS AND ELECTRIC LIGHTING.

The spread of the electric light in cotton mills is gradually but surely progressing, and it is no matter of surprise to read weekly of various mill proprietors who have adopted the coming light. The great disadvantage the electric light possesses is of a two-fold character—the initial expense of the installation involving capital, and the loss of capital and interest in the gas plants lying idle. There can be but little question that, taking the two systems fairly on their merits, the first place must be given to the electric light on all points except *one*, which is still open—that is, the question of annual maintenance. In all but small installations, basing the annual cost of maintenance in both cases on the cost of interest and depreciation, attendance and consumption of material, figures prove very conclusively that the electric light is the cheaper system of the two. This fact might have been plentifully proved from the experience of the mills themselves, but so few managers or engineers have kept any record whatever. We have, however, one recorded case which is most invaluable, and to which we shall refer in a future number. In November next a large mill at Pendleton, possessing an installation of over 900 lights, illuminated by dynamos driven by independent engines, will have been lighted by the incandescent lamps for an uninterrupted period of three years. The whole system of the electric lighting has been under the entire charge and control of the manager of the works, who has kept a careful record of the total expenditure under the two systems, which up to the present time demonstrates a clear pecuniary saving in favor of the electric light. The proprietors of the mills in question have the courage of their convictions, and in a new mill completed early this year they have had it fitted up with the electric light to the extent of about 500 lights, and to the *entire exclusion of gas.*

If in building new mills the directors of limited companies and gentlemen with capital were to enter thoroughly into the question of the merits of the two systems of lighting, they would without any doubt prefer that of the electric light; but would they uphold their "conviction?" If they did they would never repent their decision. It is in the cases of new mills where the greatest advantage may be obtained, and in such an instance as that of a new cotton mill now commencing to be built in Portwood, Stockport, the electric light might be applied with the greatest advantage and economy. The mill contains about 75,000 spindles, and will form the first portion of a scheme prepared by the Palmer Mills Co., Limited, for the erection on the site of the old Palmer mills of a modern mule spinning concern of about 140,000 spindles, with accommodation for some 10,000 ring throstles, or doubling spindles, the

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building of a second mill being included in the scheme. It has been hoped that Stockport would again occupy a foremost place in the centre of the cotton industry; in this hope the establishment generally of the electric light would be of assistance.—*Mechanical World* [Manchester, Eng.]

TIGHT BELTS.

A LARGE quantity of belt is required to transmit a little power. The sooner we investigate and believe the above fact, the better it will be for our shafting, machinery and coal heap. We may look at the fact as we please, it will bear it, and find that a slow-running belt to carry a given power must be very wide. If running at high speed, we must have the same number of square inches of belt passed over the pulley, but the belt need not be as wide to do it.

When a belt slips, the most natural action on the part of the attendant is to throw a handful of powdered rosin between belt and pulley. The next move when rosin fails, is to tighten the belt. Often we find belts strained up until they are tight enough for fiddle strings, until hangers are pulled out of line, boxes cut and shafting sprung.

A certain machine company drive their works by long loose belts which claim attention from their very looseness. These belts are 10″ to 12″ wide, about 16 feet from pulley to pulley, and are slack enough to permit the upper or slack side of the belt to "bag" down 12″ or 18″, a plane passing through the two shafts being about 45° from the perpendicular.

If this machine company had followed the example of many power users, they would have used belts 5″ or 6″ wide, strained them very tight, and have been continually troubled by the belts breaking and wearing out. The belts above described ran upon large pulleys (from 24″ to 48″) having a speed of 250 to 300 revolutions per minute.

Probably these belts would have done one-half more work than was put upon them, but from the fact of being loaded light, they did their work with very little wear and tear. They needed very little looking after, save to keep them oiled and clean.

At the Novelties exhibition at Philadelphia a centrifugal pump was shown raising a very large quantity of water, and being run with a 1½″ belt. Here, high belt-speed was used as a factor, but the little belt was strained very tight. It would soon give out, and need constant patching.

When putting up a machine to run by a high-speed belt, don't make the mistake of cutting down the width of the belt too much. Let it go wide enough to transmit the required power without being too tight.

A certain builder of lathes built a lathe to make button-hook handles. The handles were about ⅜″ or ½″ in diameter, and 1½″ long. When the belt was at its highest speed it ran over 4,000 lineal feet per minute, yet the belt was made 4 inches wide. Just think of it; a round sewing-machine belt would almost have done the work, yet here was a 4″ belt. The builder of that lathe says he would do the same thing again, for the belt service was complete; there was no slip of belt, no excessive friction, and the lathe spindle always ran true and cool.

When we see a man putting on a 14″ belt with clamps, and using a 24″ monkey-wrench wherewith to screw up the clamp-bolts, then we can say to ourselves that this man is doing a poor job.—James F. Hobart, in *American Machinist.*

A HIGH-SPEED ENGINE.

DURING the last year or two, it has come to be generally understood, that large machines, driven at a comparatively low speed, were the best for electric lighting purposes; but the lighting at the Lincoln's Inn Dining Hall and Library must be considered as an exception to this rule. The dynamo here is driven at no less than 12,000 revolutions per minute, by a Parsons high-speed engine, which justifies its title by running at the same rate. It requires some mental effort to take a statement of this kind seriously; yet there is no reason to regard the Parsons motor as a toy. It was shown in action at the Inventions' exhibition, running with unimpaired steadiness from the commencement to the close of the show. It is, in reality, a combination of turbines driven by steam, and consists of two series of parallel-flow turbines to the right and left of a central steam inlet, the steam exhausting directly from the first turbine into the second, from the second into the third, and so on through twenty turbines in each series. The steam parts with a portion of its energy in each turbine, and finally escapes at a pressure not much above that of the atmosphere. It is claimed that this is the first motor that has ever been made to work at the actual velocity of the steam, as it escapes from the boiler.—*The Engineer and Iron Trades Advertiser.*

RAILROAD CIPHER CODE.

A NEW telegraphic cipher code has gone into effect on all lines owned by the Pennsylvania Railroad Co. The volume of business daily transacted by the telegraphic department of a single divison of the company is something enormous. In order to facilitate the business of this branch of the service, a new cipher code has been carefully prepared for the heads of departments and placed in their hands. The new code refers only to railroad business and will result in a great saving of time to both officers of the company and telegraph operators. In the code certain words are used for and represent certain phrases. The cipher words are classified under various heads, as parts of the body, clothing, flowers, fruits, vegetables, minerals, titles, etc., and each of these classifications refer to one department of the railway service, which, when once learned, becomes very helpful to the officials, but which are "Greek" to outsiders. The set phrases refer, for the most part, to the movement, loading and handling of freight and passenger cars.

ENCOURAGING ELECTRICAL AUTHORS.

THE Belgian minister in London, announces that the prize of 25,000f. for the best work on a given subject, which has appeared during the preceding four years, will be awarded in 1889, to the best work on "The Progress of Electricity, as a motive power and as an illuminant, on the applications of it which are or may be made, and on the advantages arising from the employment of electricity." Works intended for competition must be forwarded to the Ministry of Agriculture and Industry before the 1st January, 1889.—*Mechanical World.*

THE ENGLISH LIGHTHOUSE EXPERIMENTS.

THE following is a summary of the conclusions arrived at by the Trinity House committee on "The Illuminants for Lighthouse Experiments":

That the electric light, as exhibited in the A Experimental Tower at the South Foreland, has proved to be the most powerful light under all conditions of weather, and to have the greatest penetrative power in fog. That for all practical purposes the gas light, as exemplified by Mr. Wigham's multiform system in B Experimental Tower, and the oil light, as exemplified by the Trinity House Douglass and wick burners in multiform arrangement up to triform in C Experimental Tower, when shown through revolving lenses, are equal, light for light, in all conditions of weather; but that quadriform gas is a little better than triform oil. That when shown through fixed lenses, as arranged in the Experimental Towers, the superiority of the superposed gas light is unquestionable. The larger diameter of the gas flames, and the lights being much nearer to each other in the gas lantern, give the beam a more compact and intense appearance than that issuing from the more widely separated oil burners.

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CORRESPONDENCE.

NEW YORK AND VICINITY.

Bids for New York Street Lighting.—Illumination of the Bartholdi Statue.—Electrical Warfare in Elizabeth, N. J.—The Meucci Telephone Co.—Legislation Regarding Telephones.—Reducing Cable Tolls.—Electric Light Dividend.—A Small Fire Started by Electricity.—A Messenger Strike on Wall Street.—Little May-moving Among the Brokers.

THE two companies which divide between them the electric lighting of the city streets and parks, continue to live in harmony with each other. Their bid for arc lamps for one year from May 1st is still at the old rate of 70 cents per night. There is no probability of competition, as new overhead lines cannot be built, and there is little prospect of a subway being provided for at least another year. The Subway Commission has secured new quarters at 1218 Broadway, where business will be resumed as soon as the governor fills the vacancy caused by the death of Hon. Charles E. Loew.

The pedestal for the Bartholdi statue is now completed, and the question of its illumination by electricity is again up for discussion. Part of the proposed plan is the location of one arc lamp on each upper corner of the pedestal, so placed as to reflect directly upon the statue, while a powerful lamp in the torch will be discernible at a distance of 90 miles at sea. The electric lights on the New York and Brooklyn bridge are mentioned in a maritime paper as still blinding the East river pilots, and states that they will probably be permitted to remain until some serious collision directs the attention of the proper authorities to the dangers of navigation under existing conditions.

Elizabeth, New Jersey, is coming into prominence as an electrical battle ground. The local telephone company entertains a prejudice against electric light wires, and when in extending a circuit on Cherry street, the Schuyler company attached its wire to a few of the telephone poles, the supposed owners of the latter sent out their men about five o'clock in the afternoon and quietly dropped the wire into the street. The consequence was that Morris avenue was enveloped in darkness, which was barely relieved by a single naptha lamp covering half a mile of the street. This interruption in the service was followed a few days later by an intermission of three nights, caused by the burning out of an armature. On the whole, the experience has not been favorable to the reliability of electricity, although this is no doubt an exceptional case.

The parent organization of the Meucci Telephone Company is also located at Elizabeth, and is preparing to do business on the co-operative principle. A central office is being fitted up, poles erected, and wires strung, and about 150 subscribers are awaiting the promised service. Local companies have been formed, or are in process of formation, at Plainfield, Newark, Paterson, Roselle, and other places. The Baltimore and Ohio company will, it is said, work in harmony with the new company.

Four different bills for regulating the rental of telephones in the state of New York were referred to the Judiciary Committee of the assembly. They differed so widely in their provisions that a sub-committee was appointed to examine the whole matter thoroughly, which resulted in the favorable reporting of a bill, of which the following is an abstract:

The first section provides for the appointment by the governor, with the advice and consent of the senate, of two competent persons as a board of telephone commissioners, to hold office for a year; neither to have any pecuniary interest in any telephone company. The second section directs said board to investigate the operations of all telephone companies operating within the state, the names and locations of all such companies, the amount of the original and present capital stock of each and every company, the cost of the plant and of operation, the amount of gross earnings of each company, and the amount of dividends declared or earned, and to report the same to the next legislature. The third section declares the board to have power to administer oaths, examine officers of all telephone companies, compel companies to produce their books, papers and other documents, or sworn copies, issue subpœnas and compel attendance, precisely as the court of record, any disobedience to be punished in a like manner as if processes issued by the courts. The fourth section provides that every telephone company shall furnish, whenever called upon by the board, any information concerning the condition, operation and management of its business. Failure to comply on the part of the company is declared to be a misdemeanor. The salaries and expenses of the board are to be collected from the several telephone companies of the state pro-rata.

The Metropolitan people consider that any action of this character is unjust at the present time, when a large expenditure will be required to place their wires underground, and the consequent abandonment of existing property in overhead structures.

A very decided reduction in cable rates has been authorized by the united cable companies, to take effect May 1st, when the existing tolls of 40 cents per word for private messages, and 20 cents for the press, will be reduced to 12½ and 6 cents respectively. Although it is not decided that the Mackay-Bennett company will meet this rate, such action is very probable.

The agreement between the Western Union and the cable companies provides that the former shall receive a fixed rate per word no matter what the cable companies shall receive. The Western Union, however, guarantees any deficit of the American Cable Company.

The Edison Illuminating Company has declared its regular quarterly dividend of 1 per cent., payable on May 1st.

A small fire is reported as having been caused by the electric light wires which enter the upper casing of a window in O'Neill's dry goods store. The firemen were summoned, who soon extinguished the flames, which caused damages amounting to about $50. The fire was so insignificant that no attention would have been given it by the daily press had it not been caused by electricity.

Labor troubles are not generally looked for on Wall street, but the messenger boys employed by Kiernan & Co. for delivering news slips to customers decided to demand an increase from $4 to $5 per week. Mr. Sullivan, in charge, refused the proposed schedule, whereupon the boys waited upon Senator Kiernan, who said they were worth the amount fixed, but his partner did not agree with him, and refused to set them at work again. The service is being performed temporarily by district messenger boys, who have not yet been educated up to the doctrine that "an injury to one is the concern of all."

May moving in Wall street this season is not so burdensome for the various electrical companies as usual. So many new office buildings have been erected that the brokers have become more generally settled down, and no great change will probably come about until a new stock exchange is erected in a different location, which is one of the probabilities of the future.

NEW YORK, April 24, 1886.

CHICAGO.

The Telephone Muddle at Indianapolis.—Any Number of Telephone Systems Ready to Accept the $3 Law.—What Constitutes Invention.—The Delusive Tests of Long-Distance Telephones.—Removal of the Van Depoele Establishment.—Lecture by Professor Carhart at Minneapolis.

AFTER a shower—toads! After telephonic legislation—telephones.

The actual number of patriotic and self-sacrificing inventors whose hearts to-day are covered with blood-clots on account of the unfortunate condition of things in the Hoosier state is something numerically wonderful. That the funeral, which so many of these philanthropists believe they are attending, should be conducted decently and in order, they are not willing. There are too many claimants for the place to allow of any deliberation or any moderation; and to advance their claims the most shameless, unblushing statements are made. Honesty, probity, and even common sense, seem to be ignored. One end alone is sought—the downfall of the enemy. They don't seem even to say, "Get money, honestly if you can." They merely say "get it."

The Indianapolis people seem dazed, and it is no wonder. To be set up as a target for all the Trays, Blanches and Sweethearts of telephony; this is too much for any sane people, and there is danger that their lunatic asylums may lack for capacity in the near future.

There was a proposition to run the exchange on a sort of co-operative system, the subscribers pooling receipts and expenses. The law makes it a penal offence to pay as well as to receive more than the fixed sum per month, and, of course, if the expenses, under such an arrangement, should exceed the legal limit, it would possibly be embarrassing if some sorehead should demand legislative investigation.

The figures which these co-operative subscribers had settled upon as the probable cost per line of so running the exchange were $4 per month, or $48, against the legal rations of $36 per annum.

Every day or two, or three at the most, up jumps a new jack-in-the-box candidate who proposes putting in his system, and shows, as clearly as words can put it, how the dear people would be benefited by taking it at once—swallowing it at the word go, bones, scales, innards and appetite, before some other chap could run under a log with it.

One of these patriotic and generous souls would sell the individual instruments to all the subscribers. Another would sell to the exchange, and this latter, by thereafter having no royalty to pay, could get a nice little plum out of the individual subscribers. Another, with still more expanded views of buncomb and business, would sell the entire state—and then, don't you see what a splendid income would accrue by leasing to the exchanges, who in turn could accommodate the public by collecting a royalty—just the same as the present plan, which the people are well prepared for. It has become, so to speak, a sort of second nature with them.

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A prominent inventor in this telephone business was once asked, derisively, "What is a patent, anyhow?" His answer is much to the point:

"I invent a coffee-pot. Another fellow sees that it is a good thing. He swaps the place of the spout and the handle, and claims it as a new invention, and not infrequently claims his as the original coffee-pot."

Now, all the plans, patents, projects and proposals of new instruments so far have, at the bottom, one of two peculiarities. They are either Bell instruments in principle, piracies on his invention, or they are not worth the water requisite to drown the inventor.

Besides the desire to wrench either credit or value from the owners of the telephone patents, there is another element in this whole matter which is worthy of consideration. There is such a thing as an inventor being deceived through lack of knowledge of the principles which he is trying to utilize; and in experimenting the novice is sometimes a long while in learning, and longer still, perhaps, in acknowledging that laboratory experiments will not always pan out when tried by the fire of actual practice.

One of the aspirants, for instance, has shown that his instrument is capable of the most wonderful long-line work, and he proves it by running a metallic loop four or five hundred miles or so and back. On this loop he places two instruments, one in the upper story the other in the basement of the same building. The result is, of course, everything that can be desired, and the experimenters are highly gratified with their success, but seem not to know that they are merely talking into and by means of a condenser. Wiley Smith says: "Tell them to take out half a mile of wire at the farther end of the loop and it will work ever so much better."

Another claims to be the only successful long-distance telephoner, and has even talked satisfactorily as far as twenty or twenty-five miles, just as easy as you can across the street, and in a whisper at that.

In the meantime nothing is being done outside the original programme, despite the wise cry of the New York and country papers of "bluff, bluff," in response to the proclamation of the company. The instruments are coming out at all the larger exchanges where contracts have expired, and more will follow when the first of July rolls round, unless some unforeseen and unexpected development thwarts the proposed action with a satisfactory solution of the difficulty.

The Van Depoele people have at last changed their base, and left the uncomfortable and inconvenient quarters they have so long occupied at the corner of Franklin and Van Buren, and removed to 15-21 North Clinton street. They have just closed a contract for lighting the Lake street bridge, which is practically a duplicate of the Rush street bridge, having steam boilers and engines for not only revolving the bridge, but for running the dynamo—all upon the structure itself.

Prof. H. S. Carhart, of the Northwestern University at Evanston, has recently returned from Minneapolis, where he delivered a lecture, profusely illustrated with experiments by the aid of the lantern. The professor had a large and interested audience, which had gathered under the auspices of the Chautauqua Circle of Minneapolis. The *American Journal of Science* for April has the professor's paper on "Surface Transmission of Electrical Discharges," read before the American Association for the Advancement of Science, in August of last year.

CHICAGO, April 16th, 1886.

BOSTON.

Great Interest Shown in Telephone Legislation.—How the Agitation Begun.—Action of the Committee on Mercantile Affairs.—Earnings of the New England Telephone Company.—Electric Lighting in the Smaller Cities and Towns.—Why the Citizens of Boston are Late at a Fire.—Important Suit against John B. Alley.—A Gas Company Authorized to Introduce the Electric Light.

BOSTON being the headquarters of the telephone business for the United States, and, in fact, of the western continent, it is natural that great interest in electrical affairs exists here, and in the legislation affecting them.

It has been somewhat difficult to the ordinary mind to conceive the animus of the fight against the telephone companies of New England, but as the hearings progressed it became evident where the trouble was. It is well known that the American Bell company when starting the business, granted short licenses for territory, and later on perpetual licenses. In the latter cases the licensees were required to give in a percentage of their capital stock. At the present time, among other companies who operate on the original *short* licenses is the one known as the Erie Telephone company, doing business in Cleveland, O., Minnesota and Texas. The company is controlled by parties who reside in Lowell, this state, where this movement against the home company originated. The Bell company has been ably represented, and most convincingly so, as the following action of the committee having the matters under consideration shows:

"The Committee on Mercantile Affairs reported inexpedient upon the order relative to placing telegraph companies, including rail and signal offices, more fully under state supervision and inspection; also upon the question of further legislation concerning the regulation and conduct of telegraph and telephone companies; also upon the order relative to uniform charges for the use of telephones and telephone service of the American Bell and other telephone companies.

"The same committee reported leave to withdraw upon the following-named matters: Petition of G. H. Manning and others for legislation defining the right of telegraph or telephone companies to maintain poles and lines of wires in public highways; petition of W. Lamson and others, that rates charged by companies manufacturing, leasing and selling, and licensing other companies to use and lease telephones, be fixed and established by law; George A. Marden and others, that the American Bell Telephone Company be prohibited from holding more than thirty per cent. of the stock of any sub-company in which it does not now own more than that proportion; petition of F. W. Stickney and others, that the right of the Bell company to hold stock in other telephone companies be limited."

And on the question of requiring electric wires to be put underground in cities, one member, being interested in telephone stock, declined to vote. The remainder of the committee was evenly divided, but one of the opponents finally consented to vote to report a bill to that effect with his name appended as dissenting.

The bill providing for the placing of wires or lines of telegraph, telephone and electric light companies underground in the several cities of the commonwealth, which is now under consideration by the great fathers, is substantially the same as the commission bill passed in New York last year, and which was published in the February, 1886, issue of the ELECTRICIAN AND ELECTRICAL ENGINEER.

A careful estimate of the recent losses to the New England Telephone Company by sleet storms the past winter, based upon actual figures for January and February, and estimating March, will not exceed $15,000. An estimate made at the time of the storms was from $20,000 to $25,000. Had they been either of these figures, the dividend for the present quarter would not have been earned. It is now apparent that the company will earn for the quarter, ending March 31, from $58,000 to $60,000, and a dividend of ¾ of 1 per cent. on the seven million block would be $52,500. It is expected the dividend will be declared some time in April. Based upon the quarter ending March 31 (exclusive of sleet-storm losses), the earnings for the quarter ending June 30 will be $75,000, or at the rate of 4.28 per cent. on the issued seven million block; or taking the present market price of the stock at 31, multiplied by 70,000 shares, $2,170,000, the earnings would be over 13 per cent.

William J. Denver, assistant general manager of the company, by a change in the method of management, will hereafter make his headquarters in Springfield. He has been in Boston since September, 1885, but from the first of this month will have charge of the western division of the company's business, which begins at South Framingham, and includes western Massachusetts, southern Vermont and southern New Hampshire.

The electric light is looking up in the smaller cities and towns in New England. The city of Malden is making preparation for the lights.

Concord is likely to have the electric light. Several have been placed in position on Main street as an experiment, and they have given great satisfaction. A large plant will be established if the people generally desire the light.

The electric lights to be placed in Salem will extend to Aborn street on Boston street, to Loring avenue on Lafayette street, to Highland avenue on Essex street, and to the draw on Beverly bridge.

Our citizens are apt to think that altogether too much time is consumed by the operators at the City Hall in giving an alarm on the tower bells. It seems sometimes as if more than a minute passes after the hook in the box is pulled down before a response is obtained; and a minute is worth a great deal at the beginning of the fire. Now, the fact is, an alarm is given in all the houses of the permanent companies the instant the hook is pulled, and the operators in the City Hall purposely wait about 45 seconds before adjusting the machinery which causes the tower bells to strike. the commissioners reasoning that it is wise to allow the firemen to get on the street some time before the general public are aware, first, that there is a fire; and second, just where the fire is. Formerly the firemen had to wait until a signal came from headquarters. Now they know, as soon as the alarm-bell operators, exactly where their services are required, and the nearest companies may get to that place before a crowd gathers.

The notable case of Chester Snow, of Harwich, against ex-representative John B. Alley, of Lynn, was begun, before Judge Thompson, in the Supreme Court at Barnstable. George O. Shattuck, of Boston, and Judge H. P. Harriman appeared for the plaintiff, and district-attorney H. M. Knowlton, of New Bedford, and Robert G. Ingersoll, of New York, for the defendant. The

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court room was packed. The action is one of tort to recover $150,000, the value of certain postal telegraph bonds. The declaration alleges that the defendant has used 150 of these bonds, valued at $1,000 each. Judge Harriman opened the case, and recited at some length Mr. Snow's connection with telegraphy. He was the one to build the first wire on Cape Cod; he also invented a wire of great merit, and of which thousands of miles were sold, and which was in use for seven or eight years, when its manufacture was discontinued, owing to certain defects. This postal telegraph company was finally consolidated with the Gray harmonic system, which was nothing but a multiplication of the Morse system, Mr. Alley holding four-fifths of the stock of this company, which he agreed to turn over for $19,000,000 worth of postal telegraph bonds, the whole capital stock being worth $21,000,000. Mr. Snow demurred against this consolidation, but the other members of the company being in favor, the consolidation was accomplished. Through the alleged misrepresentation of Mr. Alley, Mr. Snow was induced to sign a paper cancelling all claims against Mr. Alley and withdrawing the suit, but Mr. Alley did not fulfill the agreement to give Mr. Snow valuable considerations. The interest in the case is intense, all the leading men in the county being present. Chester Snow was the first witness, and testified that he never received one cent for the 150 bonds turned over to Mr. Alley. His testimony was principally in regard to the patents and his connection with Alley.

The legislative committee on manufactures have reported a bill granting additional power to the Marblehead Gaslight Company, and changing its name to the "Marblehead Gas and Electric Light Company."

BOSTON, April 16, 1886.

PHILADELPHIA.

Experimental Trial of Clay's Electro-Pneumatic Transit.—The Clay Telephone Company Tries to Free Itself from Injunction.—The Philadelphia Pole Tax Supported by Judge Hare.—Tests Made with Brown's Automatic Protector.

AN interesting exhibition of the operation of the electro-pneumatic transit was given recently before several scientific gentlemen, telegraphic officials and journalists, at Shaw and Geary's electrical works in this city. The transit is for the sending of messages through underground tubes, and is the invention of Henry Clay, of Clay Commercial telephone fame.

The main tube leading from the main office can have as many branch tubes running in any direction, right or left, as is necessary, and it does not require sub-stations along the main tube to turn the messages toward their place of delivery. Everything is worked from the main office. The message is placed in a metallic cartridge or carrier, and shot to its place of destination in a moment.

"The electro-pneumatic transit is a big improvement on the old pneumatic tube system, which requires two tubes, and the expense is seventy-five per cent. less," said George W. Bratton, who is associated with the inventor. "The mechanical contrivances are few, and when placed in their proper positions perform their allotted functions, and move from one point to another messages and parcels of small dimensions at the rate of a mile in thirty seconds. London is handling nearly 33,000 despatches a year in its post-office by the old pneumatic tube system at a pretty heavy expense. That is the reason telephones are not used to as great an extent in that city as elsewhere."

I suppose the Bell telephone Pan-Electric controversy, now going on, gave renewed encouragement to the defunct Clay Commercial 'phone people to "tackle" its great rival once more. But it is sad to chronicle the fact that the Clay contingent were sat down upon quite heavily. A few days since argument was begun in the United States Circuit Court before Judges McKennan and Butler, upon the petition of the Clay Commercial Telephone Company, for an annulment of the restraining order issued against that company in the suit of the Bell telephone company. While the argument was in progress the court intimated that it would be useless to urge the petition, as the final argument in the original suit had been heard, and the court was prepared to render its decision adverse to the Clay Commercial company, Counsel for the latter stated that if such were the case they had nothing further to say. The prayer of the petition was thereupon dismissed, and E. N. Dickerson, counsel for the Bell company, was asked by the court to prepare a final decree in favor of his client and submit it to the court at once, so that the appeal of the case to the Supreme Court of the United States could be expedited.

A few days ago Judge Hare delivered an opinion deciding the suit brought by the city against the several telegraph and telephone companies, to recover the license fee of $5 upon telegraph poles, in which he presents several interesting points of the law upon that subject.

After admitting the contention of the companies that the fee cannot be collected as a tax, he continues:

"Under the act of 1874 any five persons may unite to form a company for the maintenance and construction of a telegraph line. Telegraph companies are authorized to construct lines 'along or upon any of the public roads, streets or highways, by the erection of the necessary fixtures, including posts, rails or abutments.'

"We have here a spectacle that almost bewilders the imagination. In addition to the sewers and water and gas pipes with which the soil of our highways is already tunneled for municipal purposes, with a consequent liability to be torn up whenever a sewer bursts or a main is in need of repairs, any company to supply heat, light or power may burrow side by side with the municipality at the risk of bringing steam, water, gas and electricity into such close conjunction as will give rise to explosions like those recently witnessed in London and Philadelphia. If we look above ground we may find reason to apprehend that the occupation of the streets by structures erected for purposes which, though beneficial, are foreign to the original design, may, if these are unduly multiplied, lead to injurious consequences. Every one who considers the circumstances which I have inadequately portrayed, and the complications to which they may give rise, will agree that the city should have some supervision and control in a matter which deeply concerns her citizens, and the need will be distinctly apparent if we reflect that she is responsible for the condition of the highways, and may be made answerable in damages for a want of care in guarding against the accidents that are only too likely to occur.

"We are, therefore, unable to agree with the referee that a license fee of $5 is so clearly excessive as to justify the court in treating it as invalid. It is an established principle that remuneration should be in proportion not only to time and outlay, but to responsibility, and a public or private agent who is exposed to loss may demand higher pay. That such is the relation of the city to the various companies which have been empowered to occupy its streets with a view to gain is to me abundantly clear, and they should not grudge a reasonable compensation for the space they occupy and the risk which she incurs on their account. That the rate cannot readily be determined is no doubt true, but this circumstance affords an argument for the city, because there is a presumption in favor of the acts of public bodies within the scope of their powers. The question is not, would we name $5 as a reasonable fee, but is it so plainly in excess as to render it our duty to reverse the decision of councils? On this point, as I have already intimated, we are of opinion with the city, and, therefore, sustain the exceptions which she has filed, and send the case back to the referee for reconsideration on the above point."

Some interesting tests of the destructiveness of powerful electrical currents were recently made in the office of the Bankers and Merchants' Telegraph Company. Mr. W. T. Brown, electrician for the Pennsylvania Railroad Company, has contrived an ingenious little instrument, which he claims will effectually prevent damage to wires on buildings from dynamic or other charges of electricity. In order to show the thoroughness of the apparatus, Mr. Brown took two other protectors that are in public use, and demonstrated, by passing electrical currents through them, that they did not protect at all. Mr. Brown's instrument has been carefully perfected, and meets every possible contingency. It has passed the experimental stage, and can now be brought into public use with perfect safety.

PHILADELPHIA, April 16, 1886,

ELECTRICAL NEWS AND NOTES.

UNDERGROUND WIRES IN BROOKLYN.

SUPPLEMENTARY REPORT OF THE SUBWAY COMMISSION.

Hon. D. D. Whitney, Mayor of Brooklyn:

The undersigned, Commissioners of Electrical Subways for the city of Brooklyn, respectfully submit the following statement in the nature of a supplement to their report of September 15, 1885.

Since that date the Board has been continuously engaged in the study of the problems involved in its duty, but has seen no reason to change the conclusions which it had already reached, namely:

1. That "solid conduits" should not be extensively adopted in the present state of knowledge and experience.

2. That conduits which permit the easy change of conductors, without frequent disturbance of the streets, may be employed, leaving the questions of electrical details to the companies operating the conductors.

3. That low-tension conductors may be grouped in such conduits as to main lines: and that overhead wires may be permitted for terminal distribution, in connection with such subterranean lines; the extent of such overhead distribution being determined by the Board at the minimum consistent with reasonable practicability, and subject at all times to further reduction by the Board, when such shall appear feasible; and the location and nature of supporting poles or structures for such terminal distribution being at all times within the control of the Board.

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The New York and New Jersey Telephone Co. having proposed to lay a conduit which appeared to satisfy the conditions thus defined, and offering to give room in the same for the wires of the Police and Fire Departments; and the Western Union Telegraph Co. and the Gold and Stock Telegraph Co, having signified their concurrence in this plan and their willingness to place their conductors in the said conduit, the Board approved (with certain reservations and conditions which were accepted by the company) the construction of the proposed conduit upon certain streets.

In accordance with that approval and subsequent action of the Board, a box-conduit of creosoted wood has been laid on Fulton street, from Raymond street to Main street, and down the latter to Front street, with branches in Flatbush avenue, from Fulton to a point between Schermerhorn street and State street; and in Third avenue from Flatbush avenue to a point beyond Atlantic avenue. This line connects at the City Hall with the similar conduit previously laid through Court street to Pacific street, with a branch in Atlantic avenue from Court street to Smith street.

The system thus described has a total length of 12,420 feet, with a maximum capacity of 600 wires, or say, 1,410 miles of wire. Cables for use in this conduit have been manufactured and will be laid as soon as the weather permits.

The action of the Board in leaving, for the present, to the companies the electrical problems involved, but at the same time giving attentive hearing to all plans and devices proposed, has had a highly satisfactory result, since a considerable number of different conductors, to some of which the attention of the telephone company was called by the Board, will be tried in the conduit, and thus will receive the supreme test of prolonged practical and competitive experiment.

With regard to the simple box of creosoted wood, the Board still holds a favorable opinion, though many plans, for which special advantages have been claimed, have been laid before it by inventors and others. The concretes prepared by Mr. Dorsett and by Mr. Richardson are of excellent quality, and have been proved by use in sewers and water-pipes. The Dorsett system is moreover in use at Chicago and elsewhere for underground electric conductors, and has so far an excellent record. In approving, therefore, a further extension of the conduit already laid, the Board has felt justified in permitting the New York and New Jersey Telephone Co. to substitute experimentally for the creosoted wooden box, on certain parts of the line, the Dorsett and the Richardson conduit, with the view of testing practically the advantages claimed for each.

The additional conduit now authorized, and to be constructed immediately, will occupy the following streets: Fulton street, from Raymond street to Marcy avenue; Flatbush avenue, from between Schermerhorn street and State street to Bergen street; Court street, from Pacific street to Sackett street; Adams street, from Fulton street to Myrtle avenue; Myrtle avenue, from Adams street to Nostrand avenue; Broadway, from East River to Reid avenue; Union avenue, from Broadway to Hope street; Lynch street, from Broadway to Bedford avenue; Nostrand avenue, from Lynch street to Fulton street; Bedford avenue, from Fulton street to Prospect place—a total length of about ten miles, with a maximum capacity of 6,500 miles of wire.

The appended table shows the number of wires now strung on or near the route for which the subway has been constructed or authorized, the number which the construction of the subway will remove, and the number which will then remain.

Of these remaining wires, it should be said that they are partly city wires, over which the Board has no control, and partly wires of terminal distribution, which may be, for the immediate present allowed to remain, seeing that a certain number of poles must remain, until the city wires go underground. The Board is not prepared even to recommend to the city authorities the immediate placing of all police and fire wires in subways. The interests of order and safety in the community should not be lightly risked in such an experiment. It is hoped and believed, however, that the municipal department will be authorized to make proper trial, leading to a prudent and gradual adoption of the underground system, guided as to details by the practical experience of the electrical companies. It is, therefore, likely that for some time to come many poles will continue to stand bearing the city wires, and that many terminal wires will be allowed to remain temporarily on these poles though the ultimate result of the change in progress will be to remove all lines of poles from the main routes, and to place the terminal distributing points off the streets altogether. This is the purpose which the Board is patiently and persistently pursuing. It is satisfied with the progress already made, and believes that neither justice nor good policy nor the demand of the statute requires more violent and rapid measures.

Some time will be required for testing and connecting the new conductors; but it is believed that before the close of the coming summer a very striking transformation will have been wrought in the appearance of the principal thoroughfares of Brooklyn, and the city will have more miles of conduit and more miles of underground wires than any other city in the United States.

In its former report, the Board mentioned the fact that a conduit of creosoted wood had been successfully operated (with telephone wires alone) in Brooklyn for nine months previously. This conduit has since been opened and examined, and is still in service, thus giving an aggregate test of sixteen months' trial. Nothing was discovered by the examination above mentioned which was unfavorable to the creosoted wood as material for the conduit. But it was found that in some places the lead of the casing of the cables had been seriously corroded (carbonated) by carbonic acid, probably contained in the "water gas"—illuminating gas—which had leaked into the pipe. This corrosion would apparently have destroyed the lead casing, at the points where the action was most destructive, in about eighteen months. It was found, however, that only pure lead showed this reaction. Cables in the same conduit, the lead casing of which contained a little tin, were entirely unaffected. This discovery may lead to the exclusive employment of such an alloy for the casing of the cables hereafter, and it is believed that the ordinary lead pipe can be cheaply coated, and thus sufficiently protected.

An interesting question which will be, perhaps, answered by the competitive use of the conduits now about to be constructed is suggested in connection with the foregoing observations. The Dorsett and Richardson concrete conduits are intended to be water-tight and air-tight; and in securing this end much ingenuity and good workmanship have been expended in their construction. The wooden conduit, on the other hand, is neither air-tight nor water-tight. In its use the conductors themselves must have separate protection against gas and water. Accumulations of gas are not, in such a conduit, prevented by tight joints, but by ventilation. Theoretically it might be an advantage to have the conduit perfectly dry and free from gas. But such an underground space, if intended to be tight, and actually only almost tight, is worse than an open one. In trying these concrete conduits simultaneously with the wooden one, and under the same conditions, it will, perhaps, be possible to determine whether they present a real advantage in this respect; whether it is of such a nature as to permit the use of conductors not practicable in the wooden conduit; what is the value of the advantage, if any, and at how great a cost or sacrifice it is secured.

In justice to the Board, it should be added that the work thus far done has been prosecuted under great hindrances and inconveniences, arising from the failure of the legislature to appropriate the money necessary to carry out the provisions of the statute. Since the Comptroller is authorized to recover, by assessment upon the electrical companies, the amount required for this purpose, there need have been no hesitancy in appropriating it, but the result of the omission has been that the Board has had to rely upon the private resources of its members and pay all its own expenses. Unfortunately, several important aids to the work were beyond the means of the members of the Board—the most important being the employment of a competent inspector to watch the work of construction, and make sure that the plans approved by the Board were executed throughout in accordance with its views. This duty has been discharged in part thus far by the individual Commissioners, but the extensive constructions now about to commence will require more imperatively than ever a close and continuous inspection which cannot at all times be given by the Commissioners themselves.

The Board has at present no change to recommend in the existing statute. If the legislature will appropriate the small amount needed to carry on the work of the Board, or the Comptroller will procure it by assessing the companies in Brooklyn (which, as the Board is informed, stand ready to pay when properly notified), there will be, so far as now appears, no obstacle to the progressive, practical and satisfactory completion of a comprehensive underground system in this city for telegraph and telephone wires.

With regard to the electric light wires, the Board is not prepared to report at present.

George W. Plympton,
John Reynolds,
R. W. Raymond,
Commissioners.

THE EIGHTH WONDER OF THE WORLD.

A stranger in New York, standing on the middle span of the great Brooklyn bridge, views with wonder the beauties of New York harbor. He sees the great cities on each side stretching away for miles to the north, east and west. Beneath his feet the rapidly running river, with scores of large and small steamboats coursing up and down. A large four-masted ship, bound for China, is passing under the great bridge in charge of a tugboat on its way to the sea, all hands are busy on deck, and as she passes from under the bridge the sailors give a shout. If this ship arrives out safely and returns to this port it will be nearly a year before she makes the round trip.

Looking down the bay we see a great steamer going through the Narrows, bound in an opposite direction. Great black clouds of smoke ascend from her funnel. We know that the stokers

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away down in the boiler-room are replenishing the fires that are to furnish the motive power for the great ship, and must be attended to constantly for the next ten days.

Apparently at our feet, but over a mile away, lies Governor's Island: a picture fresh, green and peaceful. The old fort, with cannons on top large enough for a small child to crawl in, the cannon balls piled in pyramids, the officers' houses and well-kept lawns remind one of the peep show in a pasteboard box that he made when a child.

At our right we see a towering structure on an island—Bedloe's Island, three miles and a half away. It is difficult to realize the distance is so great, as everything stands out clear and bright on this beautiful spring day. This large structure is the pedestal for Bartholdi's great statue of "Liberty Enlightening the World," 142 feet high, is now completed.

The engineers and workmen who constructed the great statue will arrive from France in May, and commence putting in place this great wonder of modern times which will tower 320 feet above the waters of the bay; a beacon light that will show far out at sea, and a welcome to all who enter the beautiful harbor from oppressed and overcrowded Europe to make their homes with us.

This great statue is a gift from one great nation to another, which will stand for ages to cement the friendship of France and America.

The committee in charge of the construction of this great pedestal are nearly through with their labors. And all who desire a memento, in the form of a miniature statuette of this great work, with a certificate of subscription from the committee to show to their children's children that they helped build the great pedestal, should subscribe at once.

The statuette is a work of art, and has found a place in thousands of homes. Statuettes delivered by mail or express on receipt of subscription price, one dollar, five dollars, and ten dollars each. All remittances should be addressed to Richard Butler, Secretary, American Committee of the Statue of Liberty, 33 Mercer street, New York.

THE AMERICAN BELL TELEPHONE COMPANY.

ABSTRACT OF THE SIXTH ANNUAL REPORT OF THE DIRECTORS.

To the Stockholders:—

The year ending Dec. 31, 1885, has not been marked by the increase of business of previous years, but although there has been a loss of subscribers in exchanges at certain points, on the whole, the licensed companies have more than held their own, the total number of subscribers showing an increase of 2,969, and of telephones in use of 4,466 during the year.

The comparative statistics which follow are substantially accurate; but as usual, we are prevented from giving figures with the precision which would be possible, if the entire telephone system were managed by us directly:—

EXCHANGES.

	1883.	1884.	1885.	1886.	Decrease from 1885.	Increase over 1885.
Exchanges	725	906	764	752	12	... .
Branch offices	345	419	481	432	40	....
Miles of wire on poles	....	....	88,481	100,630	....	12,149
" on buildings	....	....	11,866	10,049	1,837	....
" underground	....	....	1,225	3,428	....	2,203
" submarine	....	....	....	264	....	264
Total miles of wire	68,571	85,896	101,592	114,371	....	12,779
Total circuits	74,484	97,422	107,268	110,967	....	3,699
Total subscribers	97,728	123,625	134,601	137,570	....	2,969
Total employés	3,716	4,762	5,162	5,344	....	182

UNDERGROUND WIRES.

	Miles of Wire Underground, 1885.	Miles of Wire Underground, 1886.	Increase over 1885.
Washington	770	992	222
Chicago	....	760	760
New York	....	627	627
Pittsburg	223	614	391
Boston	232	289	57
Brooklyn	....	134	134
Baltimore	....	11	11
Milwaukee	....	1	1
	1,225	3,428	2,203

EXTRA TERRITORIAL LINES.

	Jan. 1, 1883.	Jan. 1, 1884.	Jan. 1, 1885.	Jan. 1, 1886.	Increase during 1885.
Number of lines	247	598	826	931	105
Miles of pole lines	6,154	20,502	25,766	31,395	5,629
Miles of wire	13,658	29,359	35,631	42,461	6,830

INSTRUMENTS.

	Dec. 20, 1882.	Dec. 20, 1883.	Dec. 20, 1884.	Dec. 20, 1885.	Increase during the year.
In hands of Licensees, under rental	237,728	298,580	325,574	330,040	4,466

EXCHANGE CONNECTIONS.

The estimated number of exchange connections daily in the United States is	746,517
Or a total per year of	272,478,705
The number of calls per subscriber varies in different exchanges from 2 to 10 daily, the average throughout the United States being	5 $\frac{43}{100}$
as compared with	5 $\frac{18}{100}$
the number reported last year, an increase of about 5 per cent.	
The average cost to the subscriber varies according to the size of the exchange and the character of the service, from 2 to 7 cents per connection.	

EXTRA TERRITORIAL BUSINESS.

The average daily number of extra-territorial connections is	6,663
or a total number per year of	2,431,995
The extra-territorial earnings, as reported, amounted to	$538,740 43
of which this company's share is	$72,677 28
an increase over 1884 of	$5,411 63

Last year's statement included the connections between exchanges of the New York and New Jersey, and the Pacific Bell and Sunset companies, on the receipts from which we receive no percentage. These do not appear this year, which will account for the apparent decrease in the number of connections.

The removal of open wires from house tops to overhead cables and to underground conduits has continued, the progress in the latter respect being especially encouraging. The system must always be a mixed one, as the final distribution of wires to the customers, and the method of reaching places where underground work would be too costly, must still be overhead; but we think that, within a few years, in all large cities the open wires will be placed in cables above or under ground to such an extent, at least so far as telephone companies are concerned, that the overhead wire nuisance will no longer be serious.

In New York an amendment to the law which ordered all wires in New York city and Brooklyn underground before last November, was adopted, establishing a commission for each of these cities with power to supervise the execution of the law, and to arrange for placing the wires underground to such an extent as might be found practicable.

In Brooklyn the commission has permitted the wire companies to begin their work, and 134 miles of underground wire have been placed there by the telephone company. In New York the Metropolitan company in August, 1885, filed with the commission the necessary plans and statements for an underground system, and applied for permission to prosecute the work, but so far without success, and this work in that city is at present at a standstill.

The treasurer's statement to December 31, 1885, shows gross earnings for the year, from all sources, of		$2,765,884 93
Expenses		972,688 45
Net earnings		$1,793,196 48
Miscellaneous credits		16,800 00
Total		$1,809,196 48
Regular dividends paid	$1,170,192 00	
Extra dividends paid	392,044 00	
Total	$1,562,236 00	
Reserve written off for depreciation of instruments	100,752 90	
		$1,662,988 90
Balance to surplus account		$147,007 58
Total surplus to date		$1,204,120 01

We have received during the year in stock of licensed companies, $516,316.67, of which $207,200 was for licenses, and the rest for cash, and have sold $29,631. We have received during the year in dividends from licensed companies, $597,469.99, an increase of about $122,000 over the previous year.

* * * * * *

During the year a pole line has been built between New York and Philadelphia, with a capacity of 70 wires, and 24 copper wires placed upon them, various sizes being taken for purposes of experiment. Some difficulty has been found in securing rights of way for this line. Sufficient facilities are not

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yet secured in Philadelphia for reaching customers there, but it is expected that this will soon be accomplished, so that the question of commercial demand between two large cities a hundred miles apart will presently have a fair test. The Metropolitan company, of New York, pays for and owns over one-half of this line, and will divide the expenses and receipts with us. The line is practically completed, and, with 25 wires, will cost about $215,000.

* * * * * * *

The Canada company has had a year of prosperity in spite of the adverse action of the government in annulling the Bell patents. Their subscribers have increased from 7,418 to 9,614, in fact more than in any previous year. The company gives good service, is not discouraged by threatening legislation from extending facilities as fast as needed, and has increased its net earnings from $119,000 in 1884 to $158,000 in 1885.

* * * * * * *

Regarding the proceedings of the Pan-Electric company and the proposed government suit, the stockholders will naturally feel much interest, and the facts will be stated somewhat in detail:

The Pan-Electric Telephone Company was organized in 1883, with a capital of $5,000,000, the ostensible basis of value for which was a group of patents, some of which related to telephones, of one Rogers. Its headquarters are in Memphis, Tennessee, which is also the home of Senator Harris and others of its promoters.

These patents are perhaps the most palpable infringements upon the Bell patents that any one has yet attempted to rely upon; there is not even the pretence of any invention prior to Bell, and the inventions are of no importance whatever. The company had apparently so little to offer, that it was for a time difficult to see what they expected to accomplish, either in the establishment of a telephone business or in starting a legal contest.

The principal stockholders were leading politicians in the southern states, and their operations, so far as the telephone business goes, have been mostly confined to that part of the country.

General Joseph E. Johnston, of Virginia, was made president of the company, Senator A. H. Garland, of Arkansas, its attorney, and Senator Harris, of Tennessee, General Johnston, Senator Garland, Casey Young, J. D. C. Atkins, of Tennessee, J. H. Rogers, formerly of Tennessee, now of Washington, D. C., and Robert F. Looney, of Tennessee, its directors.

These gentlemen received large blocks of the capital stock, paying nominal sums in money for the same. Sub-companies were formed, from whom bonuses in cash were taken for the right to practise the Rogers inventions in different places, and additional blocks of the stock of these sub-companies appear to have come to the promoters. On Jan. 4, 1884, Mr. Garland was asked for an opinion on the Rogers patents. One D. E. Myers, who said that his attention had been drawn to the stock of the Pan-Electric company, wrote as if for information upon a matter of investment, but it appears that Myers was himself in the service of the Pan-Electric company, and was therefore not interested in buying its stock, but in selling it.

Mr. Garland replied upon the following day, giving what from its tone purports to be a professional opinion, to the effect that he had carefully examined the Rogers patents, and that he was clear that they in no way infringed the Bell patent. Nothing contained in his letter indicated that he was interested deeply, as a stockholder, in the market value of the Pan-Electric stock. Upon this opinion largely, it appears, the bonuses were obtained from sub-companies, and efforts were made to sell Pan-Electric stock.

Yet it is clear that the right to practise the Rogers inventions could have no substantial value under any circumstances. If the patents now controlling the telephone business could be declared void, the Pan-Electric would only share the telephone field with all comers, and the rights for which the bonuses and stock were taken are of wholly imaginary value, while Mr. Garland's opinion about the Rogers patents was not shared even by his associates, since it was renounced by them at the hearing before secretary Lamar, when they squarely stated that if Bell's patents were valid the Rogers patents infringed them, and they did not propose to contest that point.

The first way in which the influential names were to be used was, therefore, in getting money for supposed rights which had no value. The second was perhaps equally ingenious, but so far not as successful. It was a plan to get the suits of the Bell company against the Pan-Electric company and associates stopped. The programme for accomplishing this was as follows: In 1884 an attempt was made to get a statute through congress, authorizing the government to bring suit to have patents vacated under certain circumstances. This measure was got through the house almost unnoticed, but it did not pass the senate committee on patents.

This move failed, but after Mr. Garland became attorney-general, and the other Pan-Electric leaders received important positions under the government, it was decided without the aid of any statute to ask attorney-general Garland to order a suit brought to annul Bell's patents, on the ground that he obtained them by fraud, and that he was not the first inventor.

Mr. Garland declined to act, but left Washington for Arkansas, and his next in office, Mr. Goode of Virginia, within a day or two of his departure, received a similar request from an associate company of the Pan-Electric, called the National Improved Telephone Co. of New Orleans, and upon one day's examination decided that there was reason and authority for consenting, and he ordered the suit brought, not in Massachusetts where our company exists, but in Memphis, Tennessee. He further placed in charge of this suit, with authority to proceed in the name of the government, the very man who is the most active manager in the Pan-Electric enterprise, namely, Casey Young, its secretary and treasurer, and Geo. B. Gantt, also a stockholder, and Luke E. Wright, of Memphis, and J. R. Beckwith, of New Orleans. For some reason these men were so confident that the suit would be ordered, that they had a bill all ready (printed beforehand in New Orleans), which was immediately filed in Memphis.

As soon as Mr. Goode ordered this government suit, counsel for the Pan-Electric appeared in Baltimore before Judge Bond, who was about to hear our application for injunction against that company, and asked for a postponement of proceedings, for the reason that the government suit was a valid objection to a preliminary injunction, thus exposing the motive of the whole movement. This request was not granted, a restraining order against the Pan-Electric company was issued, and the court will hear the case in due course.

The President, finding that Mr. Goode's action had been taken without reference for information to the department of the interior, suggested to the department of justice, that it would be better to conform to usage in such matters; and the suit was withdrawn. A new request was then preferred and sent to the department of the interior for information. The secretary of the interior, Mr. Lamar, of Mississippi, gave a hearing, lasting a week, on the question of the government suit, at which Messrs. Dickerson, Smith, and Storrow, appeared for us. Without considering the merits of the questions involved, he advised that the government had a right to bring such a suit, and also that it should do so, apparently because there was an allegation of fraud involving officers of one of the departments, which, for some reason not explained, he thought could alone effectually be investigated in a suit by the government itself; but he advised that the government should conduct its own case and at its own expense.

On the 1st of February our suit for injunction against the National Improved company in New Orleans, the associate of the Pan-Electric company, was reached. Once more the counsel for our opponents appeared, with the request that the case be postponed because the secretary of the interior had advised the government to bring suit against us, and that other cases ought not to be heard until that was decided.

It is easy to understand the injury to the Bell interests that would follow if the United States courts should refuse us all protection against infringement until the government could try over again and determine all the questions relating to the priority of the telephone invention, which it has taken us eight years of arduous litigation to bring to their present condition of readiness for the Supreme Court.

The court at New Orleans refused to stay proceedings, the arguments have just been heard and we hope for an early injunction in this case.

Here then the whole programme lies exposed: a plan to sell rights that had no value on the strength of prominent names;—a plan to wreck our property by stopping our suits, pending years of wholly unnecessary litigation;—a plan to deceive the public into the belief that the defeat of the Bell patent would confer value upon Pan-Electric stock;—a plan to inveigle Mr. Cleveland's administration into support of this scheme.

If such a plan can succeed, what interest in this wide country is safe from an infamous attack? If any doubts have existed as to the expediency of a statute permitting such action on the part of the government, the proceedings of the Pan-Electric associates, and the fact that they could secure the aid of such men as Mr. Garland, Mr. Harris, and General Johnston, ought to put an end to them. If there is any reason to believe that such power is already within the reach of the government, without a statute, can any one doubt that it should be removed by immediate prohibition from congress?

If the government, upon a simple allegation of fraud in the obtaining of patents or other government grants, made by interested parties, can be called upon to bring suits either at its own expense, or under the management of the interested party, to annul its own agreements, any poor inventor may have his fortune wrecked by powerful competitors; any owner of property based upon government agreements or land or other grants may find the government, on whose faith he has expended his money, appearing before its own courts, in favor of some irresponsible or dishonest claimant.

It has been urged that nothing but the annulling of our patent in suit, by the government itself, would suffice to enable others to enter the telephone field. There is no weight in this, for with every decision in our favor, we have barely been able to keep the

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field free from serious infringement, and it is certain that one decision by the United States Court invalidating our patent would be enough to flood the country with competing companies.

It seemed inconceivable, that upon this state of facts, the essential parts of which were already public, the government should lend any countenance to such an enterprise. We felt entire confidence that Mr. Lamar would advise that, at least under such circumstances, the two parties interested should be left to fight their battles before the courts in the usual way, and his decision took us wholly by surprise.

When he made it public, it seemed proper to place the facts in the case before the President; and the president of your company went to Washington, and had an interview with Mr. Cleveland. The latter was told that the present owners of the Bell patents, had bought them in good faith, in the belief, which they still entertained, that they were properly obtained, and were valid; that on the strength of United States patents, and repeated decisions of the United States Courts in their favor, the parent company and its licensees had invested vast sums of money in putting this invention into use throughout the country; that the sum of fifty or sixty millions of dollars were now at stake in the business. That every issue which the government was asked to raise, was already in the records of several cases that had been argued and passed upon by the United States courts, which were already far on their way to the Supreme Court, on appeal, and that the first of these cases was expected to come up in October. That we had expended eight years of litigation, involving over fifty days of argument by the ablest counsel we could procure, the taking of over 5,000 pages of testimony, and the expenditure of half a million of dollars. That our licensees could not but view with alarm the prospect of going once more over this expensive and tedious road, in the face of a suit brought by the government at the instance of a company which they believed to be wholly speculative and irresponsible.

It was shown that the programme of the Pan-Electric company was to get our suits stopped, and not tried, and to avail of official influence to get this accomplished, and it was explained how thoroughly our property could be destroyed without trial, could the existing suits be suspended while the government suit was slowly making its way to a decision.

But the government adheres to the advice of Mr. Lamar, and on the 23d day of March, filed a bill against this company and our licensees in Ohio, at Columbus, Ohio, before Judge Baxter, who would also have heard the case had it been brought at Memphis. Messrs. Thurman, of Columbus, and Lowrey, of New York, with several others, have been selected as counsel, and it is not our belief that the management of the suit is to be left within the control of the Pan-Electric company, or that the government intends to allow any unnecessary delay to be interposed in its prosecution. It is to be noted, however, that it has taken this distinguished group of counsel over two months to decide the questions which Mr. Goode disposed of in a single day.

While there has undoubtedly been a wide-spread feeling of anxiety among our stockholders and licensees, at finding the power of the government thrown into the scale before its own courts, under the circumstances just described, our counsel and the directors feel no uneasiness as to the result of such a suit, as all the matters involved have been the subject of repeated decisions.

Regarding the question of locality of a government suit, we are advised by counsel that jurisdiction can only be had over us in Massachusetts.

It is said that government seeks to find a place where no telephone cases have yet been heard, but if this be true its attitude is not easy to understand.

If the subject has already been passed upon, it cannot under established usage be again considered by the Circuit courts, and if it is new, a court which has already made itself familiar with matters relating to telephone inventions, would seem to be the one most likely to give quick and intelligent despatch to the business.

To assume that there is any prejudice in our favor in the various courts before whom our suits have been heard would be an indictment of a large part of the judiciary by the executive, for which there can be no justification.

Regarding the newspaper agitation that has attended this Pan-Electric exposure, it is proper to say that we have taken no part in it, directly or indirectly. While it would have been wholly within our right to place all the information within our reach in the possession of the press, we felt that having adopted the course of going directly to the government with the facts as we understood them, it was the proper course, at least under the then existing circumstances, to take no part in any discussion in the newspapers.

Yet it has been impossible to avoid a sense of outrage at the whole transaction, and the support it has received in official circles, which made it difficult to maintain silence, and we feel that this full statement of the matter is due to the stockholders.

* * * * * * *

Referring to the legislative regulation of telephone rates in Indiana, the report says:—

A case testing the validity of the law was brought and carried up to the Supreme Court of Indiana, and the Central Union Company, doing the telephone business of Indiana, gave testimony beyond dispute that telephone service in Indianapolis and other cities actually cost that company more than $8 per month per subscriber. That court has recently decided that the law is valid, but has accompanied this decision by language which implies a doubt whether the law is either wise or just. The court based its opinion largely upon the so-called police power of the state, which is said to confer the right to control matters affecting the safety and convenience of the public, and quoted the case of a restriction enforced against the patent owners of a dangerous oil in behalf of its position.

But there is no question as to public safety involved in the telephone law, and as the telephone is certainly a convenience to the public, of less consequence than the supply of food and clothing, it does not seem probable that the right to regulate the telephone business, even without considering the question of patent right, exists, unless the state has the power to regulate prices of all other commodities. If this general power does exist, surely the patent right must give some protection to a business which wholly depends for its peculiar value upon patented inventions.

The court made the distinction that the price for the right to practice the invention could not be interfered with, but that as soon as the invention was embodied in a tangible article like the telephone, the state possessed the right to limit the price for the use of it. This is to assert that the state has only to take one step round in order to practically accomplish that which the court itself says it must not do, and this whole ground is so opposed to the generally accepted theory upon which patented articles have been bought and put into use, and to the whole theory of the patent law, which purports to ensure full protection for the exclusive use of the invention during the life of the patent, that it seems incomprehensible that the view of the Indiana court can be correct.

In consequence of this decision the Central Union Company is obliged to close its exchanges in the principal cities and large towns; there seems to be no other course, unless the company is willing to do business at a heavy loss, until the rate law can be repealed. The public will necessarily be put to serious inconvenience, and the telephone company is helpless to give relief. In Ohio and New Jersey similar bills, which were before the legislatures of those states, have been rejected or postponed, and we have every confidence that the same result will be reached in several other states, including Massachusetts, where the same legislation has been attempted.

The Indiana case is to be appealed to the United States Supreme Court, and the result will be awaited with anxiety by many others than those interested in telephone property. If the states possess such right as is claimed by the Indiana court, the motive of public policy should still operate against its exercise. Why should the telephone business be regulated as to price more than other industries? The reasons offered are that telephone companies are monopolies, and that they have been granted certain privileges of location, but as they are monopolies only by virtue of the patent system, which is everywhere accepted as a part of our public policy to which all the states are committed, no state, in fairness, ought to destroy that which this patent system has created, and the privileges of location which have been granted them are so precarious that sufficient obstacles are already placed in the way of conducting their business, by their being obliged to put their money into plant of such uncertain tenure. Sound public policy is surely against the regulation of the price of any class of commodities by law. If it is admitted with telephones, it may presently be proposed for anything else which the public wants.

In the discussion of this matter, the circumstances that these patents are property bought and paid for seems often to be wholly overlooked by those who are proposing to distribute the benefits of the telephone to the public. It is the buyer using his majority vote to fix prices, without reference to the rights of the seller. It is often asserted that telephone rates are too high, but the assertions are unaccompanied by any proofs, and those who make them do so without that knowledge of the business which is necessary to a fair judgment.

With the improvements which are rapidly coming into use, the aim must be nothing less than to provide a complete working system throughout the United States, which will give facilities for instant conversation between all points within many hundred miles of each other, such as is now possible within the limits of a single exchange. This cannot be accomplished by competing companies, each reaching only part of the persons wishing to become subscribers to such a system. The service is divested of half its value the moment half the people retire to a second system, and of much more should there be still further sub-division. In other words, the value of the thing consists in placing each person in the same system with each other one, and this can only be done under one general plan.

The contracts which we have made with our licensees are all shaped with this complete general telephone service in view.

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For purposes of inter-communication between existing smaller systems, it is arranged that all shall work together, and the fact that the telephone companies throughout the land have been held under such a general plan by the force of a government patent, has been and is of the highest importance to the public, for in no other way could even the present condition of telephone development have been reached so soon, or without great confusion among competing companies and the multiplication of the wire nuisance, which would have been intolerable.

To any one who will think what it would mean, if instant verbal communication could be had by any person here with every city and town in New England, and as far as Philadelphia, perhaps even Washington and Chicago, with similar facilities in all parts of the country, it must be clear that this is something well worth the risk of money, thought, and labor by the companies; well worth encouragement from the people. The work that has been done is at least some guaranty of what will follow, if the protection promised by our patents is not interfered with. The public is ripe for the use of such a convenience, the inventive talent of the country is providing new methods for making it available—will the legislatures interpose to prevent all progress, through misconception of the problem, or because misled by interested parties?

What has already been accomplished has been under every discouragement that can be thrown upon a property resting on patent rights. But a small percentage of patented inventions prove valuable, and all such are usually compelled to run the gauntlet of lawsuits from pretenders, so long as their patents live. Capital, therefore, is timid about such investments, and nothing but the expectation of large temporary returns will bring it out for the development of a business like this.

While it is true considerable returns have been received upon our property since 1883, it is equally true that for years we were without dividends or other income from our investment; our patents have but seven years more to run, and we are still working, as always before, under a heavy fire and an expenditure for defense, which nothing but a prospect of liberal returns would, for a moment, justify.

To undertake such a work as has just been outlined, large sums are required for construction. It is within the power of state legislatures to so alarm capital that might be attracted to such a business, that it would be wholly useless for a time to attempt any important work of the kind suggested. The attack upon rates is one of the most direct methods of removing all inducement to extend telephone facilities; but, even if the right to absolutely regulate this matter were conceded, the question whether the few thousand persons, who now are connected with telephone exchanges, shall have telephone service a little cheaper than at present, is of trifling importance to the country, compared to the completion of a telephone system adequate to the needs of the whole people.

The directors feel that the outlook ahead is promising, that there is good prospect of an early favorable termination of our most important suits, and strong reason to hope that further unjust legislation will not be seriously attempted, so that we may look forward to an opportunity to devote ourselves to the extension and completion of our telephone work.

For the directors,

W. H. FORBES, *President.*

THE STORY OF PAN-ELECTRIC.

ATTORNEY-GENERAL GARLAND'S EXPERIENCE WITH POKER, TELEPHONES, AND THE LAW.

The investigation of the Pan-Electric scandal, which has continued at Washington during the past month, was enlivened on April 19th by the examination of attorney-general Garland. It was nearly one o'clock when he tottered into the committee room and seated himself in the witness chair. Men who had not seen Mr. Garland recently were shocked by the change for the worse in his physical condition. His face showed traces of pain and sickness, his hands were cold and clammy, and his voice at times was weak and unsteady. He frequently refreshed himself from a glass of water, and when he left the witness chair he seemed nearly exhausted. Mr. Garland told his story in a candid way that created a favorable impression, and he answered readily questions which would have thrown Casey Young into spasms of indignation. There is a great difference between the two men. Mr. Garland's statements, under oath, that he had tried to make money out of poker and the law, with indifferent success in the former pursuit; that he and his partners were "impecunious" men who embarked in the Pan-Electric scheme in order to better their condition, and that the enterprise had not "panned out" as well as he could wish, perhaps were less dignified than one might have expected from the attorney-general of the United States; but they were made with an air of frankness which was almost captivating.

It appears that while general Atkins was still a member of congress he induced Mr. Garland to embark in the speculation. The witness insisted that the stock was not a "gift;" but he admitted that he paid nothing for it. He testified to the genuineness of the published copies of his legal opinion in favor of the Pan-Electric patents. Mr. Garland's account of the efforts to have the government suit brought was more clear and satisfactory than his explanation of the reason why he entertained the Van Benthuysen application of July 12, to the extent of referring it to the interior department for a report and advice.

Some of Mr. Garland's testimony contradicted that of Mr. Goode on a material point—the object of such reference. Mr. Garland denied, of course, that he had any hand in the bringing of the suit; but he said that when he declined to consider the application of Van Benthuysen, Gantt and company, he "supposed" they would go to Mr. Goode for a remedy. He said that he did not intimate to them that that would be the proper course. He declined to express any opinion whatever respecting the validity of the Bell patent, except that when he wrote the letter to Meyer on the subject of the Pan-Electric patents he had an idea that the "broad claim" of the Bell could not be upheld.

On the whole, Mr. Garland's testimony did nothing to shake the impression produced by the evidence of other witnesses, that the government suit was ordered by Mr. Goode as the result of the Pan-Electric-National Improved agreement made immediately after the application to him, to which agreement Messrs. Young, Harris, Gantt and Van Benthuysen certainly were privy.

Mr. Garland said that he wished to lay before the committee and reaffirm the matter contained in his statement to the President on October 8. In addition, he wished to explain two or three points of that statement. In February, 1883, general Atkins said that he believed the Rogers inventions were of great utility if properly handled, and that money could be made out of them. He suggested that Mr. Garland enter into them. "I told him," said the witness, "that I had never undertaken to make any money except by law and poker. I had always lost at poker and generally won at law. I was willing to go into this if he thought it offered any inducement." Senator Harris made substantially the same statement about the inventions, and two or three days afterward the witness was introduced to Dr. Rogers and his son at their home. It was an inference, and not a fact, he said, that the Pan-Electric company made the application to bring suit against the Bell company. The inference was founded on two reasons: that colonel Young came with the other gentlemen in the latter part of July, and the witness knew him to be the secretary and treasurer of the Pan-Electric, and because the witness, on May 25, received a letter from Dr. Rogers, requesting suit to be brought as a stockholder of that company. Coupling these facts together, witness took it for granted that the Pan-Electric made the application—it was simply an inference, and no name was mentioned. He treated Dr. Rogers's letter as personal. He knew that Rogers had no authority to make the application, and, therefore, the letter remained unanswered. In July Van Benthuysen presented his application for a suit, basing it on the law, which he stated, had been passed at the last session of congress. Mr. Garland had heard of the law before that, and had had some search made, but could not find the act. The application, however, was so well written, and apparently set out the passage of the bill so positively, that he felt that there must be some mistake, and that the bill had become a law. The application was referred to the interior department, where it should have gone in the first instance, and the witness heard no more of it until it was returned last January with the other papers. After receiving Van Benthuysen's letter, he set to work to examine into the matter. Looking over the authorities, he had concluded that he could not order a suit, and when Van Benthuysen, Young and the others came, he determined that he would not touch it at all under any circumstances.

While still in the senate, senator Platt came to him one day with the bill to authorize government suits and asked his opinion of it. The witness looked it over and said that he regarded it as unnecessary—that it would do no good. That was all he ever said or heard of the bill until it was brought to his attention through the application. In the early part of the fall a Mr. Humphreys, of the Globe Telephone Co., called upon him at the department about the application. "I thought he was going to jump over on me," said the witness. Humphreys insisted that the witness should order a suit, and said that it was curious that because Mr. Garland was in another company that Mr. Humphreys's rights should be disregarded. "He got mad because I would not do anything about it," said the witness, "and we parted not with mutual respect and admiration at all."

Mr. Garland denied that he had ever given an opinion about the validity of the Bell patent. The opinion he had given and the only opinion was to the effect that the Pan-Electric inventions were not infringements; that they were improvements upon telephones that were differently patentable—a well-recognized principle. While a stockholder he had been derelict in attending meetings for the reason that the place of meeting was inconveniently situated and that the meetings were held at night, when he rarely went out of his house. Although he was attorney

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for the company, Mr. Young and senator Harris usually drew up the legal papers and when they were referred to him he made such alterations as seemed to be necessary. These papers were submitted to him in the senate judiciary room, but it was a mistake to say that any board meetings were held in that room. He was satisfied that he had never attended a meeting of the company since the last presidential election.

Mr. Garland said that he arranged to leave Washington on August 27 and spend the entire month of September at his home in Arkansas. He chose that time because he had found September to be the best month to be out of Washington, and because he could shoot deer in Arkansas in that month under the game law. "The deer did not become ripe until September," said he. Mr. Goode returned about the middle of August, but Mr. Garland said nothing to him about the application he had received, because he did not know exactly what to say. He supposed the gentlemen who had made the application would find their remedy if they supposed they had one. When he came back to Little Rock he received a despatch from *The New-Orleans Times-Democrat* saying that his admiring newspaper friends were complimenting him on ordering suit against the Bell company. He replied that he had not ordered any such suit He returned to Washington about October 1, and when he called at the White House the President told him the papers were speaking of the case, whereupon he made the explanation that was published. He never opened his mouth to Mr. Goode about it, because as solicitor-general Goode, under the statute, was perfectly free and independent, and Mr. Garland had no more control over him in his absence or disability than he had over gentlemen in congress. He had never to this day spoken to Mr. Goode about the first suit or the one alleged to be pending. Mr Goode said something about the counsel and the practice of the government in dealing with counsel, but Mr. Garland did not know what was in the bill, had never seen the papers on which the suit was predicated and had never talked with secretary Lamar or the gentleman who had sat with him. He even declined to talk with the President about the suit. One of the gentlemen in Secretary Lamar's department—Zach Montgomery, an old college friend and appointed at his solicitation—declined to sit in the case because of his friendship and old acquaintance with the witness.

Mr. Garland had seen some notice now and then about Garland being the recipient of a block of stock by way of a gift. Of course he said there was no gift about it. As to the question of propriety there was no more impropriety in his position than in the case of gentlemen holding railroad stock sitting in congress, or congressmen going over to the Supreme Court to practice for money. It was a legitimate business and he had never dreamed of any legislation being asked. His only regret was that it "had not panned out better." If any question had come up in congress connected with the company he should not have voted on it. He recommended Dr. Rogers and his son to Messrs. Cox and Hewitt because he regarded them as competent men in their line. We talked with architect Clarke about Harris Rogers's application for appointment as house electrician, and about putting in the Rogers telephones, but after a consultation with senator Edmunds, the President pro tempore of the senate, Mr. Clarke refused to make the appointment.

The chairman inquired if Mr. Garland regarded the stock as a gift.

Mr. Garland replied in the negative. Five or six persons had come together for the organization of a company and they had made assessments, the first move being to give a note of $1,000 which was followed by assessments of $50 or $100 each. He did not regard the inventions as having any marketable value; the company was to establish their utility and put them on the market.

Chairman Boyle—Did you contemplate using your official position for the advantage of the enterprise?

Mr. Garland—Not at all. If I had been a private citizen I could have done much better than when in office. I had no more idea of using official influence than of jumping into the Potomac river with a mill-rock around my neck. The company was simply an undertaking by half a dozen impecunious gentlemen. They never tried to boom the business and scatter the stock upon the country; at least I never heard of it.

The chairman asked why the witness wanted to put telephones in the capitol.

The witness replied that they wanted to exhibit the instruments to the public; it was not intended to bring them before congress.

In answer to a question by the chairman, the witness said that he had never had a patent case in his life.

Mr. Hale inquired for the witness's understanding of the reason for referring applications to the interior department.

Mr. Garland replied that it was simply for information and such suggestions as they might see proper to make in the premises, it was advisory, of course.

Recurring to his vacation, Mr. Garland said that, believing Mr. Goode would not return in season, he was about to send for Mr. Maury. Under the statute Mr. Goode had the right to act as well in his disability as in his absence, and he expected, when he refused to entertain the application, that the gentlemen would go at once to Mr. Goode. He did not know that they would follow that course, and had not suggested it. He went to his home at Hominy Hall, Arkansas, leaving instructions to send no departmental letters to him. The house was "fifteen miles from Little Rock and seventeen miles from anywhere else."

Mr. Ranney inquired whether the witness regarded his stock a purchase, as he had said it was not a gift.

Mr. Garland replied that it was not precisely a purchase; it would be difficult to define it in one word. Still, taking the assessments into consideration, it might be called a purchase. He was $400 out by the assessments.

Mr. Ranney wished to know to what extent he had acted as counsel for the company.

Mr. Garland replied that, as he had stated, he had looked over the legal papers brought to him by others, but he had not performed any other duties as attorney.

Mr. Ranney asked why the witness, feeling that parties had a right to be heard, that they should not be deprived of that right and the duty devolving on the solicitor-general—had not referred them to the solicitor-general.

Mr. Garland answered that he did not want to be concerned in the matter at all. After he had examined it he concluded that it would be better for him not to suggest where the applicants should go. Certainly the gentlemen looked mad when he refused to touch the matter.

Mr. Ranney—Did Casey Young look mad?

Mr. Garland—Casey did not look well pleased.

Continuing, the witness said that Mr. Young did not open his mouth after introducing the gentlemen. It was due to all sides that he should state the fact that after he had declined to take any action in the matter of ordering suit, a number of prominent legal gentlemen wrote to him insisting that, notwithstanding his connection with the Pan-Electric, it was his duty to bring the suit. Some of the most prominent men in the country wrote to that effect.

Mr. Ranney objecting to the statement, saying that he did not care to go into what people had written, the witness remarked that he was simply trying to show his position at the time.

Mr. Ranney wished to know if the witness had felt that it would be improper to tell the applicants that he was disabled and refer them to the solicitor-general.

"It would not have been improper," responded the witness, "but it was a question of delicacy with me."

Mr. Ranney—Don't you think you were a little over-sensitive?

Mr. Garland—No, sir; with me it was a case like that of Lorenzo Dow's man. "You will be damned if you do, and be damned if you don't." [Laughter.]

Mr. Ranney, referring to the previous testimony concerning the witness's refusal to hear the application and subsequent search for the missing law, asked how he knew that another application would be made.

Mr. Garland replied that he did not know that; he only supposed that the parties would return to request the reference of their application to the solicitor-general, then they had also threatened to appeal to the President.

Mr. Ranney inquired if it had occurred to the witness as a reason for not telling Mr. Goode of the receipt of the application, that if he told him of his action in refusing to consider the application, that Mr. Goode might feel bound to reject it; while if he said nothing Mr. Goode would act upon it as an original application, and might grant the request.

Mr. Garland responded firmly in the negative, and as Mr. Ranney still pressed him for his reason in remaining silent, he remarked that after what had occurred it seemed to him that it was with the utmost propriety that he kept silent. He thought it would have been extremely indelicate to have said anything about it. Later on, referring to the *Times-Democrat* despatch about the order for the suit received by him at Little Rock, the witness said that when he received it he had to think some little time to recall just what it referred to.

Mr. Ranney pointed out what he said was a discrepancy in the testimony relative to the withdrawal of the original application. Van Benthuysen had sworn that he told the attorney-general he intended to make application to a district-attorney, while the witness did not remember any such statement.

Mr. Garland replied that he had "sawed off" the conversation very short, and he still failed to recall any such statement.

Mr. Oates—Since you have been attorney-general, have you done any act or thing, directly or indirectly, to enhance the interests of the Pan-Electric company, either as counsel for them, as stockholder or interested party?

Mr. Garland—I cannot call to mind any thought, action or word of mine since I have become attorney-general that is calculated in the remotest degree to increase the value of that stock or enhance its value in any way. I have not been at a meeting, and have had no conference with the gentlemen connected with it at all.

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Mr. Oates asked whether it was a very unusual thing for a district-attorney to make such applications, to which the witness responded in the negative.

This concluded the examination of the attorney-general, and the committee adjourned until Wednesday, April 21.

THE $2,000,000 SUIT AGAINST THE WESTERN UNION.

In the suit brought against the Western Union Telegraph Co., ex-senator Conkling, representing the old Bankers and Merchants' Telegraph Co., spoke for an hour and a half upon the subject of the raid made upon its wires by employés of the defendant in July, 1885.

Mr. Conkling said:

"This is not an action for trespass, as has been claimed, telegraph instruments, disconnected wires, the franchise and good-will to do business are not real estate. Neither does the destruction of it all by Goths and Vandals or by a tyrannical, domineering monopoly or corporation make it real estate. It is a case of traver and not trespass. The major wrong is the destruction of property. Wires not in dispute between the Bankers and Merchants' and the American Rapid companies and not within gunshot of the border land of dispute were ruthlessly cut down. Some of these were leased as private wires for great rentals. This corporation (the Western Union), emboldened by the power behind it, cut, hacked and ruthlessly destroyed; struck down and demolished the whole thing; took from us $80,000 a year in rentals. This pending suit shows well that we want them to come before twelve men, drawn by lot, to answer for this vandalism. That of all things on earth they mean never to do—if the resources of counsel can prevent it.

"No posse was sent out, no note addressed to any of the legal gentlemen on whom the Bankers and Merchants' relied for advice, no warning was given. But a muscular posse with a legal posse behind it ordered and accomplished this piece of barbarism and paralyzed a great business, which had just as much a public right as the postal system. Now they say that a suit commenced to ascertain the ownership of property in dispute ought first to be settled, after having taken the short and brutal way of anticipating its settlement. Brought to book for all this, they want to tie fast the victim on whom they committed this ungodly outrage. They snatched property, saying 'it is ours.' Invited to answer to all the facts, whether justified, or misled through a misapprehension, they are not willing to try it in that way, but say wait until another case has been decided. This suit is solely in respect to the rights and property of the Bankers and Merchants'. Whether this was a confused and amalgamated mass of property has nothing to do with the cause. Judge Shipman said that so crying was this offense that, while he could not hear the main issue he felt called upon to make an order compelling the Western Union to keep within boundaries."

Referring again to the voluminous papers and affidavits presented by counsel for the Western Union, Mr. Conkling said: "They went before Judge Wallace with reams and volumes of affidavits sworn to by its myriad of servitors, with which this corporation, at a whistle or nod can garrison a court-house." Ridiculing the position taken that the pendency of a case in the Federal court removed the damage suit from the jurisdiction of a state court, he drew a number of analogies to show the absurdity of such a position.

"Isn't that their case?" he asked of Col. Ingersoll, whose fat sides were shaking.

"I'll swear to it," was the rejoinder of the great hereafterless.

"If I understood Judge Dillon rightly," continued Mr. Conkling, "he does not ask the discretion of the court. They come here demanding rights. If that is so then this motion must be to restrain a multiplicity of vexatious suits. Is it possible at this day that marauders, corporate or otherwise, can go about preying upon and destroying the property and business of their neighbors until the rendition of a judgment is given in a prior litigation in spite of which they acted?

"This whole affair was a piece of colossal deviltry and a cowardly act, because no notice was served. Even the meanest of reptiles gives notice by its rattle. Harland was a conspirator, for he knew when he signed that agreement with the Western Union that they meant to go and steal, carry away and wreck the business of the Bankers and Merchants'. He must have known it, else why was he indemnified for all that could possibly follow, which he must have known would happen?"

"An agent indemnifying the principal," interrupted Col. Ingersoll.

"Yes, that's just it," remarked Mr. Conkling. "The law books used to say that agency in fraud or tort was impossible. The law keeps on saying so and will continue to do so, notwithstanding the new interpretation put on it by the Western Union's counsel."

After recess Aaron J. Vanderpoel closed the argument for the Western Union. He paid his respects to the senator for having ruffled him on the previous day by terming his speech a very pleasant one, but the terms "guerrilla," "thieves," "bandits," "marauders," as applied to the Western Union, would have no effect. The Bankers and Merchants' company, he claimed, was only a corporation on paper and took the property of the American Rapid company. He stated that the question at issue in the suit in the United States Circuit Court was whether the agreement between receiver Harland, of the American Rapid and Western Union should be confirmed. But receiver Farnsworth filed his answer three days before the present suit was commenced. This, he maintained, made the suit for damages dependent on the settlement of the other. Judge Vanderpoel's argument was cut short by a dispute among counsel provoked by several statements as to facts.

Col. Ingersoll made a brief statement and Judge Andrews took the case under advisement.

THE VACANCY IN THE SUBWAY COMMISSION.

The appointment of a commissioner to succeed the late Charles E. Loew is creating considerable interest in local political circles. The New York *Times* of April 26 gives the following gossip upon the subject:

"The leaders of Tammany Hall are making a desperate effort to have governor Hill appoint some friend of the wigwam as a member of the Electrical Subway Commission, in place of Charles E. Loew. While, under the law creating the commission, the power of original appointment was vested in the mayor, the controller, and the commissioner of public works, it was provided that all vacancies should be filled by the governor. In fighting to have one of their number appointed, the Tammany men are not very modest in their claims. They say that Mr. Loew was a Tammany man, and that therefore the place belongs to the wigwam. There are few people, however, who have such short memories as to forget that the dead commissioner long since severed his connection with Tammany, because of the ingratitude of many of its leaders. Even within the organization there are many persons who are ready, at the first opportunity, to fight the men who fought Loew, and to prevent their recognition by the governor.

"A conference of some of the district leaders was recently held, at which it was announced that Rastus S. Ransom, at one time the law partner of ex-president Arthur, would like to succeed Mr. Loew. Mr. Ransom has become quite popular among the Tammany men who now control the organization, and his claims were at once given attention, some of the leaders going so far as to make a direct request to the governor to appoint him. It is said that Mr. Ransom's appointment would be particularly pleasing to Jacob Hess, who, with Theodore Moss, is on the Subway commission. The Tammany men, however, have other candidates for the place, although no name other than that of Mr. Ransom has as yet been mentioned. A meeting of the leaders will shortly be held, at which the matter will be discussed, and a plan of action will be determined upon to bring governor Hill into line.

It is not known just when governor Hill will appoint a successor to Mr. Loew. He has before him the applications of over 40 gentlemen who are anxious to help put the wires underground. It is said that he favors naming some prominent electrician, so that the commission will at least have one expert on the subject under consideration. In this view, if he really has adopted it, he only follows out the belief expressed by mayor Grace when the commissioners were first appointed. The mayor's view, however, was outvoted by controller Loew and public works commissioner Rollin Multiloquous Squire. If the governor is disposed to appoint an honest expert, he may effectually block the game to control the commission on the part of Maurice B. Flynn and his syndicate of greedy and unscrupulous capitalists, who want to enrich themselves at the expense of the people of the city. A great deal will depend upon the character and firmness of the new commissioner. If he is fearless, independent, and disinterested, he can accomplish a great deal of good; if, on the other hand, he is some Tammany time-server or a backsliding businessman, he can do a great deal of harm. Commissioners Hess and Moss say that nothing will be done in the way of agreeing upon a plan until after the governor has made his appointment. Senator Daly, who introduced the original underground wire bill in 1884, has had the senate pass a resolution calling on the commissioners for a report of the result of their labors. This resolution is believed to have been introduced in the interest of certain men who have a subway plan which they think is going to be adopted by the commission. They are fearful, however, that delay may spoil their scheme, and so they would like the commission to report at once. This plan is the Johnstone or Philadelphia plan.

The promoters of the Dorsett system of asphaltum concrete conduits have by no means given up hope of being able to have their plan adopted. Mr. Dorsett is to construct a five-mile section of conduits in Brooklyn, under the direction of the subway commissioners in that city, and he fully expects to get all the work both in Brooklyn and in New York. He is also going into the Johnstone territory in Philadelphia and to Boston. He is now erecting a factory on the east side of this city which is expected to flood the east with conduits, as his Chicago factory has been doing for western cities.

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THE HENRY ELECTRIC RAILWAY.

The Henry Electric Railway Company of Kansas City, of which J. C. Henry, an old telegrapher well known in the western country, is electrician, is now engaged in the development of an electric railway system, and have obtained some practical results worthy of notice. The motor, which is now in operation, weighs 1,000 lbs., and the car, when empty of passengers, 6,000 lbs. In an experiment made a few days since it was coupled to a freight car weighing 24,500 lbs., and started without difficulty up a three per cent. grade. The car was run with a dozen passengers a distance of half a mile, up a 2½ per cent. grade and round a succession of sharp curves in two minutes actual running time. We know no instance in which so good a result has been attained on an ordinary standard-gauge line.

THE FARADAY ELECTRICAL CABLE COMPANY.

The patents and plant of the Faraday Electrical Cable Company have been leased by the American Electrical Works of Providence, R. I., where the cables will hereafter be manufactured. The Faraday cable is made up of cotton-covered wires in any required number, the moisture having been removed from the cotton fibre, which is treated with an insulating material. The whole is enclosed in a lead shield, outside of which is a braid of cotton or hemp, saturated with a waterproof substance. These cables have always been very carefully made, and experts who have tested them are well satisfied with the results obtained. The plant will hereafter be under the management of Mr. Eugene F. Phillips, which is a sufficient guarantee that the same high standard of work will be maintained.

NEW YORK BRANCH OF THE AMERICAN ELECTRICAL WORKS.

At 15 Cortlandt street, this city, a branch office of the American Electrical Works, with the energetic colonel Geo. L. Beetle in charge, has been established. The plan is one they have contemplated for some time, only delayed until the right man could be engaged to represent them. This they have secured in colonel Beetle, widely and popularly known, and the combination thus perfected carries with it all the elements that comprise an unqualified success. These electrical works have a splendid reputation for furnishing first-class goods, and their new enterprise is founded on the demand that is sure to follow where customers are pleased and the field is increasing.

REMOVAL OF A. G. DAY'S OFFICE.

Extensive alterations in the Equitable building, 120 Broadway, have compelled the removal of Mr. Clark B. Hotchkiss, general agent of Day's kerite wire and cables. He has secured quarters at 16 Dey street, near the Western Union building, where he is readily accessible to his numerous friends.

A MONSTER ELECTRIC TOWER.

An iron tower, 984 feet high, is to be erected on the grounds of the coming Paris international exhibition. The tower will be supported by four pillars, which will be higher than the towers of the Cathedral of Notre Dame, which have an altitude of 295 feet. The structure will cost $1,000,000, and will be surmounted by a powerful electric light that will be visible, it is believed, as far as Dijon, which is 197 miles southeast of Paris.

THE TELEGRAPH IN MEXICO.

In his recent message to congress, president Diaz states that the reorganization of the telegraph system, under the administration of the director-general of telegraphs, Mr. Saturnino Yslas, has already shown important economic results.

It is but a few months since he assumed the duties of the office, and that he has already succeeded in effecting noticeable reforms, confirms the wisdom of his appointment.

MANUFACTURING AND TRADE NOTES.

The Detroit Electrical Works have closed their New York office, 33 Astor House, and have made arrangements with the well-known house of E. S. Greeley & Co., successors to L. G. Tillotson & Co., 5 and 7 Dey street, to represent them in the east. Messrs. E. S. Greeley & Co. will carry a full line of the Detroit Electrical company's manufactures, which they will sell at factory prices. Mr. T. H. Angell, the former manager of the Detroit Electrical company's New York office, has resigned to go into other business.

The Johnson Carbon Co., North Adams, has just turned out its first product of carbons for electric lights, to the number of 20,000. They have a complete set of apparatus, furnaces, presses, etc., and will be able to turn out from 5,000 to 10,000 daily.

The St. Louis Carbon Works, with plant in East St. Louis, have been enlarging their capacity of late by general improvements.

The improved flexible cords made by the Western Electric Company are meeting with great favor. The new form of conductor has many advantages for either telephone or switch board purposes.

Owing to the large demand, the Western Electric Company has been obliged to increase its facilities for the production of disque Leclanché batteries.

INVENTORS' RECORD.

Prepared expressly for The Electrician and Electrical Engineer, *by* Pope & Edgecomb, *Solicitors of Patents for Electrical Inventions*, 11 *Wall Street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From March 16th to April 6th, 1886 (inclusive).

Alarms and Signals:—*Fire Alarm*, A. C. Gordon, 338,593, March 23; *Time Register and Alarm*, C. W. Whited, 338,323. *Hotel Call-bell System*, J. L. Beers, 338,697, March 30. *Indicator*, J. W. Howell, 339,058. *Circuit closing Attachment for Pressure Gauges*, M. W. Grovesteen, 339,094. *Fire Alarm Transmitter*, W. C. Shaffer, 339,485, April 6.

Clocks:—*Circuit-closer for Clocks*, C. H. Pond, 338,773, March 30. *Alarm Clock*, G. H. Davis, 338,935. *Step-by-step Mechanism for Clocks*, J. E. Carey, 339,264, April 6.

Conductors, Insulators, Supports and Systems:—*Metallic Telegraph Pole.* S. H. Terry, 338,115, March 16. *System of Generating Currents*, C. J. Van Depoele, 338,321, March 23. *Subway*, C. C. Gilman, 338,518, March 23. *Means for Suspending Electric Lights*, T. H. Brady, 338,919, 338,920, March 30. *Insulated Wire*, W. M. Habirshaw, 338,733. *Underground Conduit*, J. M. Jagel, 338,971. *System of Distribution*, T. A. Edison, 339,279, April 6. *Apparatus for Laying Submarine Cables Underground*, H. C. Spalding, 339,341. *Cap-iron for Poles for Suspending Electric Lights*, T. H. Brady, 339,371.

Dynamo Machines and Motors:—*Clamp for Dynamo Brushes.* M S. Eldon, 337,824, March 16. *Commutator Brush*, L. W. Stockwell, 337,885. *Dynamo*, C. J. Van Depoele, 337,896, 338,320; G. Forbes, 338,169; C. Batchelor, 338,383, March 23; R. E. Ball, 338,692, 338,910, March 30. *Regulator for*, same, 338,333. March 23. E. Thomson and E. W. Rice, 339,979, March 30. *Reciprocating Engine*, C. J. Van Depoele, 337,897, March 16; 338,375, March 23. *Motor*, W. H. Darling, 337,981, March 16; E. M. Bentley, 338,023; W. H. Knight, 338,085; Geo. H. Stout, 338,622, March 23; V. E. Keegan, 338,976, 338,977, March 30. *Oiler and Wiper for Commutator*, J. Snowberger, 338,197, March 16.

Electrolysis:—*Apparatus for Forming Wire by Electrolysis*, M. G. Farmer, 338,941, March 30. *Apparatus for Electrotyping*, W. J. Ladd, 339,431, April 6.

Galvanic Battery:—J. Serson, 338,194, March 16. *Pocket Battery*, G. Otto, 338,770, March 30.

Ignition:—*Fire-arm*, S. Russell, 337,872, 337,873, March 16. *Gas-Lighting Burner*, C. W. Holtzer, 338,747, March 30. *Gas-Lighting Apparatus*, same, 338,748.

Lamps and Appurtenances:—*Carbon for Incandescent Lamp*, C. J. Van Depoele, 337,899, March 16. *Incandescent Lighting Apparatus*, H. P. Brown, 337,923. *Arc Lamp*, E, and H. Walther, 338,122; Geo. A. Mayo, 338,352, March 23. *Automatic Cut-out for Lamps*, E. Thomson and E. W. Rice, Jr., 338,208, March 16. *Manufacture of Hard Carbon*, J. J. McTighe, 338,542, March 23. *Apparatus for Producing Hard Carbon from Hydrocarbon Vapor*, same, 338,605. *Apparatus for Producing High Vacuums*, C. F. Reinmann, 338,551. *Pump for Producing High Vacuums*, same, 338,552. *Artificial Resistance*, H. P. Brown and F. Herbert, 338,708, March 30. *Lamp Holder*, F. Schaefer, 339,217, April 6. *Lamp Switch*, same, 339,218. *Incandescent Lamp*, C. R. Arnold, 339,253.

Measurement:—*Volt-ampère-meter*, L. Waldo, 338,120, March 16. *Galvanometer*, O. E. Lundstedt, 338,178. *Apparatus for Measuring Currents*, J. L. Huber, 338,596, 338,597, March 23. *Meter*, J. S. Raworth, 338,549; S. Z. De Ferranti, 338,588.

Miscellaneous:—*Vote-recording and Indicating Apparatus*, C. O. Vale, G. F. W. Holman, and W. J. Barnette, 338,009, March 16. *Safety Catch for Translating Devices*, W. H. Knight, 338,084. *Thermostat*, M. Loomis, 338,090. *Spring-jack Wedge*, H. Anderson, 338,131, March 16. *Cash and Parcel Car*, G. F. Green, 338,150, 338,224. *Armature for Magnets*, C. A. Gaiser, 338,260, 338,261, March 23. *Watchman's* Time Detector, L. W. Pennell, 338,292. *Circuit-closing Device for*, same, 338,293. *Watchman's Time Recorder*, J. E. Tarbox and E. H. Taylor, 338,315. *Poise Adjuster*, C. W. Hastings, 338,522. *Automatic Coupler*, J. S. Raworth, 338,550. *Lead Press*, W. A. Shaw, 338,561. *Cash and Parcel Transfer*, G. F. Green, 338,663. *Belt*, J. H. Woodward, 338,683. *Magnetic Separator*, C. Schaeffer, 339,017, March 30. *Horse Unhitcher*, A. J. Coffee, 339,043. *Time Recorder*, A. C. Frieseke, 339,092. *Submarine Torpedo Boat*, G. E. Haight and W. H. Wood, 339,096. *Signal Recorder*, A. J. Coffee, 339,381, April 6. *Process of Treating Wines and Liquors*, E. J. Fraser, 339,540, 339,541.

Protectors:—*Automatic Safety Circuit Controller*, O. F. Jonsson, 338,752, March 30. *Automatic Cut-out and Lightning Arrester*, P. P. Belt, 339,363, April 6. *Lightning Arrester*, J. Horen, 339,417.

Railways and Appliances:—*Railway*, E. M. Bentley, 338,022, March 16. W. H. Knight, 338,080, 338,081, 338,082, 338,083, 338,174, 338,175, F. J. Sprague, 338,619, March 23. W. M. Schlesinger, 339,018, March 30. T. A. Edison, 339,278, April 6, *Railway System*, F. J. Sprague, 338,318, March 23. *Signaling Apparatus for Trains*, W. R. Ray, 338,439. *Conduit for Electric and Cable Railways*, H. T. Clay, 338,485; E. E. Ries, 338,556. *Electrically Actuated Locomotive*, F. L. Pope, 339,073, March 30. *Railway Signal*, A. Castro, 338,927. *Electrical Switch*, E. H. Johnson, 339,298, April 6.

Telegraphs:—*Register*, L. Winterhalder, 338,328, March 23; F. B. Wood, 338,329. *Printing Telegraph*, S. D. Field, 338,343, 338,344. W. J. McCausland 339,312, April 6. *Transmitter*, G. W. Baldrice, 338,691, March 30. G. H. Lasar, 338,757. *Branch Circuit for Quadruplex*, W. Maver, Jr., 338,996. *Multiple Telegraphic Repeater*, same, 339,449, April 6. *Stock Quotation Telegraph*, P. Kenny, 339,558.

Telephone Systems and Apparatus:—*Telephone Mouthpiece*, J. Miller, 337,972, March 16. *Transmitter*, J. T. Guthrie, 338,263, March 23; J. F. Dann and J. Lapp, 338,492, 338,660; W. C. Turnbull, 339,121, March 20; S. P. Thompson and P. Jolin, 339,499. April 6th, S. P. Thompson, 339,501. *Telephone*, J. E. Dann and J. Lapp, 338,491, March 23. *Mechanical Telephone*, A. W. Steiger, 338,620; H. Lamont, 338,983, March 30. *Magneto Telephone*, S. P. Thompson, 339,500, April 6. *Telephone Switch*, W. C. Turnbull, March 30. *Battery and Switch for Telephone Systems*, C. A. A. T. De St. Aubin, 338,938. *Pneumatic Acoustic Telephone*, J. A. Maloney, 338,994, 338,995.

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NEW YORK, JUNE, 1886.

WINDING UP THE PAN-ELECTRIC TELEPHONE INVESTIGATION.

THE congressional investigation of the Pan-Electric Telephone Company, which, after dragging its slow length through many weary weeks, without developing anything of particular importance, had apparently nearly reached its close, a few days since developed what was intended as a startling and sensational surprise, in the shape of still another affidavit from that already somewhat notorious affiant, ex-patent office examiner Wilber, which was introduced by the opponents of the Bell patent. This affidavit, which we reprint in another column, is chiefly interesting as showing the straits to which these parties have been brought in order to support the charges of fraud and corruption in the patent office in respect to the proceedings in the matter of the respective telephone inventions of Bell and Gray, which have filled the columns of some of the leading newspapers for the last few months. The affidavit, which is a lengthy one, is in the form of a confession, in which the ex-examiner says that he was at that time in the habit of borrowing money from Mr. Bailey, who was the attorney for Bell, which he repaid, not with sordid cash, but by "expediting" the cases of Bailey's clients, and what is more important, if true, that after the withdrawal of the official notice to Gray respecting Bell's interfering application, that he showed and explained Gray's caveat to Bell, and that Bell, in grateful recognition of his kindness, took him around into a back hallway and presented him with a $100 bill. This is the substance of the affiant's story, but in view of his previous record, as given by himself, it is apparent that but little credence can be given it.

In the first place, admitting that Bell did acquire a knowledge of the contents of Gray's caveat, which if we are not mistaken, he has denied under oath, yet the fact remains, that he did not make any changes in his specification which had any relation to the subject-matter of the speaking telephone. In the second place it is notorious, that at the time when Bell was prosecuting this application, he was so poor that he was dependent upon friends for assistance, almost from day to day, and it is little less than preposterous to suppose that he would have paid an examiner one hundred dollars for a service which, as his own subsequent actions showed, was of no possible use to him.

The following editorial from the New York *Evening Post*, of May 22d, very clearly points out the fallacy of this class of evidence.

The Pan-Electric people fired their heaviest projectile yesterday, the same being an affidavit from Z. F. Wilber, who was an examiner of interferences in the patent office at the time when the original Bell patent was granted. The committee of investigation declined to receive Mr. Wilber's affidavit, the time for receiving testimony having passed. Nevertheless the precious document was handed to the newspapers, and to one of them in sufficient season to supply itself with a wood engraving of that part of the patent office in which Wilber says he was bribed by Professor Bell in person. Wilber's own account of himself is that he was then in the habit of being bribed by Bell's attorneys through the process of borrowing money from them and not paying it back. Since that time he has been in the habit, he says, of making false affidavits while under the influence of liquor, said affidavits to be used in important lawsuits. In this way it comes about that the present affidavit contradicts some of the former ones relating to the same subject-matter. This one, he says, is positively the last and is given "for the sake of justice and the easement of his own conscience." He thinks it is quite likely that Professor Bell will deny the bribery, but that his (Wilber's) "mind is now clear and his conscience active." He then introduces the diagram of the rooms and corridors, showing exactly where he stood and where Professor Bell stood when the latter handed him a one hundred dollar bill. This is the diagram with which the *Times* illustrates Wilber and itself this morning. The one hundred dollar bill, he says, was given to him after he had shown Professor Gray's caveat to Professor Bell. It is not stated whether a bargain was struck beforehand that Wilber was to show the caveat to Bell for one hundred dollars. The implication is that the money was given in the way of gratuity to a hard-working officer of the government whose expenses customarily exceeded his income.

No step taken by the Bell company in this investigation has so fatally discredited the Pan-Electric crowd as this Wilber affidavit. Setting aside the fact that Bell made no use of the information (if he received any) of the nature of Gray's caveat, the whole story, the acknowledged character of the witness, the contradictory nature of his several affidavits touching the same subject-matter, make up a picture which excites both derision and pity—derision for those who rely upon such testimony to establish a truth, and pity for the poor tramp who has made such a sorry exhibition of the remnants of a Union soldier. Mr. Wilber ought to be in an asylum for inebriates or in some other secure refuge, where patent lawyers are not allowed to enter. The protection of public charity should be extended to him, in order that he may not be induced to commit further perjury, and so that respectable and well-meaning public journals may not be exposed to the folly of printing his "after-davits."

The telephone inquiry has developed no new fact. A great deal of time has been consumed, and a vast deal of stationery has been used. The public has ceased to read the testimony or to care anything about it. All that has been gained is a record, supported by the oaths of witnesses, mostly reputable, of facts previously known.

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Attorney-general Garland's position is neither better nor worse than it was in the beginning. It is in proof that he declined to do anything in reference to the Pan-Electric suit for the reason that he was a party in interest or one who might be charged with having an interest. It did not occur to him that his having an interest and being attorney-general at the same time were two incompatible and irreconcilable facts. If the Pan-Electric company had the right to ask the attorney-general to bring a suit to vacate the Bell patent, that right was not to be defeated by the attorney-general's interest. If the solicitor-general had happened also to have an interest, was the application to be denied altogether and without reference to the facts in the case? While Mr. Garland's offence was more of form than of substance, it was quite sufficient to create a scandal, and the misfortune is that it is a continuing scandal, keeping step with the telephone litigation in all its phases.

ELECTRIC RAILWAYS AND TRANSMISSION OF POWER.

It is gratifying to note that throughout the country there appears to be a growing interest in this very important branch of electrical industry. Practical work is being done and investigations pursued, which are destined to develop into very important business enterprises. The methods pursued are in many instances conservative, and the progress made, may not harmonize with the reputed energy of our people, but it should be remembered that this is a very expensive line of experimenting, and however satisfactory the results, a large proportion of the mechanical devices used must be superseded, as experience develops defects or weaknesses which must be provided against to meet the exacting demands of commercial usage. We are pleased to note that the exchange of views at the February meeting of the National Electric Light Association in Baltimore, has exercised considerable influence in this direction, and the definite statement that more money could be made in selling power, than in producing light, has led to further investigation of this important subject. The seed planted there will require considerable time to produce actual financial returns in the form of dividends, as in many instances existing companies are so situated that customers cannot be obtained. Others, however, may see their way clear to engage in the business at once. There is of course a great deal of quiet work being done, which is very properly concealed from the public, but enough is known to prove that the problem is being practically and successfully grappled with, and that the utilization of electricity in the industrial field will soon cease to be a novelty. When it was thoroughly understood that selling light was in reality selling power, every effort was directed toward the economy of producing steam. So close has been the competition to achieve the best possible results, that great advances have been made in the adaptation of the steam engine to the generation of electricity, so that it appears very probable that the loss of power by transformation through dynamo and motor, is less to-day, than it was by the best mechanical methods generally used ten years ago.

In conjunction with this subject it is not out of place to mention the fact that satisfactory progress is also being made in the use of secondary batteries which are destined to be a most important factor in perfecting any system largely engaged in supplying power, and also for the operation of street railways in many localities. In fact it has been asserted by practical men that electric light stations could not engage extensively in leasing power until a suitable plan of storage could be devised, as in the winter months the resources of a station would be overtaxed for two or three hours per day, when there would be a maximum demand for both light and power. Possibly the proposed eight hour movement will remove this difficulty.

THE INSTITUTE MEETING.

The general meeting of the American Institute of Electrical Engineers on May 19th was a very successful gathering, and proved conclusively that the present scope of electrical subjects is sufficient to permit of the building up of a useful and flourishing society, which may be, not only independent, but capable of conferring upon its members a recognized professional standing, which will be exceedingly beneficial in the future development of electrical projects daily opening up before us. The importance of closer intimacy between representatives of the various electrical industries is very generally recognized, and the Institute promises at an early day to pave the way toward this most desirable result, by establishing monthly meetings, which, with the possible exception of a summer vacation, will afford advantageous opportunities for the presentation of papers, and the discussion of the various topics of interest which are frequently brought before the public.

In order to obviate so far as possible that oppressive air of formality which pervades gatherings of this character, it is proposed that members convene at about 6 P. M., and join in a supper to be provided at a moderate price, which will afford an opportunity for all to become better acquainted with each other, and consequently lead up to greater freedom in the discussion of such questions as may be brought up in regular session at a later hour. Although not officially promulgated, this plan has already received the approval of all the officers and members who have considered it, and there appears to be no reason why such gatherings should not become exceedingly popular, uniting as they do upon a common platform of good fellowship where the physicist, the electrician and the amateur may be entertained, and mutually instructed.

It is continually asserted that America is not abreast with the times in the character of its electrical gatherings. This is by no means the case. The tendencies of our people to associate for various purposes, is strikingly apparent in the electrical fraternity. Without giving the official titles, and possibly omitting many which are unknown to us, the following may be mentioned as organizations composed of electrical craftsmen: The American Institute of Electrical Engineers; the New York Electrical Society; the Buffalo Electrical Society; the National Electric Light Association; the National Telephone Exchange Association; the Telegraphers' Mutual Benefit Association; the Telegraphers' Union; the Telegraphers' Mutual Aid Society; the Gold and Stock Life Insurance Association; the Railway Telegraph Superintendents' Association; the Train Despatchers' Association; the New York Electrical Club; the New York Telegraphers'

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Chess Club; the Military Telegraphers' Association and the Old Timers' Association. As will be seen by their titles these various organizations in most instances have been founded for special purposes, and most of them are active and efficient societies. Many persons who are eligible are identified with several of them, and their combined maintenance requires a sufficient expenditure of time and resources to refute the idea that electrical America is backward in association work. Given a well defined object, officers interested in the cause, and success will follow if it is deserved.

IT WAS A SPEAKING TELEPHONE.

One of the props which has been relied upon to support the telephone brigands in their raid upon the Bell patent, has been rudely torn away by Professor Nipher. After a trial of the instrument known as "figure 7" (see page 124, April issue, vol. v., Electrician and Electrical Engineer), Dr. Wellington Adams decided that it could not be made to talk, and made an affidavit to that effect which was included in the evidence presented before Secretary Lamar last winter. Before the affidavit was used however, supplementary experiments by Dr. Adams, assisted by Professor Nipher, were more successful, resulting finally in the positive proof that the instrument not only could, but did talk. An affidavit to this effect was afterwards filed in connection with and contradictory to the previous testimony of Dr. Adams. Subsequently Dr. Adams sought to correct his previous statement by submitting a supplemental affidavit which, however, does not appear to have been accepted, and the Pan-Electric attorneys seem to have no further use for Dr. Adams. If it be admitted that the instrument as shown in "figure 7" will not talk, it is scarcely reasonable to suppose that the granting of the patent would have been considered sufficiently important to have instigated the acts of bribery and corruption which are alleged to have accompanied its passage to issue. The same energy which has been devoted to the attempt to transmit speech through the Reis transmitter would doubtless have proved that Bell's original instrument would talk.

There is one exceedingly depressing thought in connection with the Pan-Electric investigation; that is the probable amount of telephonic scandal which will be inflicted upon the public during the next presidential campaign. It will then be conceded that not only do some telephones talk, but that all their adherents are adepts in the same line.

MUNICIPAL TELEGRAPH SERVICE.

The very important part enacted by the telegraph, telephone, and fire alarm in connection with the Chicago riots, has directed the attention of the municipal authorities in all our large cities to the necessity of perfecting their various systems of inter-communication. The frequency of fires, and the unquestionable advantages of an efficient fire telegraph have so stimulated improvement in this particular branch, that in all American cities of any pretensions, the systems are all that could be expected. Police telegraphs however, have never received the same amount of attention, and in many cases, are no improvement upon prevailing methods of twenty-five years ago. The police patrol system, first introduced in Chicago, has however been brought into prominence, by reason of the very efficient manner in which it hastened the concentration of the force at any required spot, immediately upon the slightest indication of trouble. As wagon after wagon dashed up to the scene of the riots, each depositing its full complement of officers, fully equipped and fresh for active duty, the moral effect alone must have been exceedingly impressive. Any person who has witnessed the rapid assembling of steamers and trucks at a fire, will appreciate this wonderful display of thorough organization and discipline which appears by its very momentum to bid defiance to all turbulent elements. The very quiet and mysterious manner in which these widely scattered forces are suddenly brought to a common rallying point adds greatly to the grandeur of the scene.

So thoroughly are our citizens now convinced of the necessity for preparing against emergencies of this kind, that no objections will probably be raised to the thorough equipment of New York with the most improved devices which can be suggested tending toward the perfection of our system of police protection. Now that attention has been drawn to this subject, and there exists a probability of reform in police telegraph service, invention in this line will doubtless be stimulated, with a fair prospect of ultimately reaching the same degree of perfection existing in connection with the fire department.

REAPING THE WHIRLWIND.

Every possible legal device has been resorted to by the Western Union Telegraph Company to prevent the Bankers and Merchants' suit for damages from going before a jury. These efforts were not successful and the evidence is now being heard by twelve good men and true. The defense is apparently directed principally toward proving that the property seized was lawfully subject to the care of the Western Union company, and that it was therefore proper to take it wherever found. Whether this will be considered sufficient justification for the manner in which possession was obtained is a question to be settled in the courts. For the sake of law and order, it is to be hoped that some less offensive method of wrecking rival companies will be pursued in the future.

THE NEW COMMISSIONER.

Renewed interest in the underground question in this city will doubtless follow the recent appointment of Mr. Roswell P. Flower to fill the vacancy caused by the death of Mr. Loew. The fact that he acknowledges his entire ignorance of the technical questions involved will by no means hasten the work, unless he accepts for granted the conclusions already arrived at by the other members of the commission, but which they have not yet felt sufficient confidence in to publish as an official decision. Mr. Flower expresses the opinion that the law should be enforced, but his views upon this point may be slightly modified after he has carefully studied the provisions of the act. If he will take the 118 plans which have been submitted, and retire to his accustomed summer resort, and carefully digest them, he will doubtless return next autumn fully convinced that his mind is not as clear upon the question of enforcing the law as it is at the present time.

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ARTICLES.

ON TELEPHONY, AND THE OPERATION AND FUNCTIONS OF THE INDUCTION COIL IN TRANSMITTERS.

BY THOMAS D. LOCKWOOD.

(Concluded from page 166.)

THE curious feature about the application of the induction coil to the battery transmitter, is that it practically restores the apparatus to its magneto principle of operation, although few, I think, have recognized this. Yet, when pointed out, the truth of the observation is very apparent. One of the most salient characteristics of the magneto transmitter is that it generates currents of alternately opposite sign. One of the characteristics of the battery transmitter when incorporated actually in the line circuit is that it does not generate any current, but that it varies the strength of an existing current without reversing it. But when we add the induction coil, we once more actually generate currents, and not only so, but they are of rapidly alternating direction.

This is inevitable, when we consider the nature of the case. In *any* induction coil, it is well known that if the circuit of a current flowing in the primary coil is rapidly made and broken, or if the current itself be intermitted or alternately, and rapidly strengthened and weakened, independent electrical currents are induced in the secondary coil and line, and these currents are of constantly changing direction.

Irrespective of the direction of the primary current, if its strength be increased, an induced or secondary current is developed, which has a direction opposite to that of the original or inducing current; while if it be weakened the induced current in direction is identical with the primary current. In this respect, therefore, even if in no other, the battery transmitter when combined with the induction coil in the way I have described is analogous to the magneto transmitter.

The currents it originates in the main line are of the same general character. They are alternating in direction.

The induction coil comprises a short primary coil of comparatively thick insulated wire; a core of soft iron, or a bundle of soft iron wires (more frequently the latter), passed through the centre of the primary coil, and surrounded by it; and a very long coil of insulated wire, which is wound over the primary coil, and which is called the secondary coil. There are two ways of setting up induced currents in a coil of insulated wire. One is to produce an alternate ebb and flow, so to speak, or an alternate presence and absence of a current of electricity in a primary coil in close proximity to it; the other is to vary the strength, or the position of a magnet, so placed with respect to the coil, that the convolutions of the coil cross its lines of force. If we analyze the operation of an induction coil, we find that the currents developed in the secondary circuit are the combined effect of both actions.

Every one must have noticed the great difference experienced in the intensity of shocks taken from an ordinary medical coil when the same coil is tried first with the core inserted, and then with the core drawn out; and it is found that the portion of the current flowing in the secondary coil, which is due to the changes in the magnetism of the core, is of higher E. M. F. than the portion which is developed by current induction from the primary coil.

The primary coil has a compound function; it first, by virtue of the battery current flowing therein, magnetizes the soft iron core; when now the strength of that current is varied by the action of the circuit changer or circuit breaker, the variation of strength accomplishes two final results. It effects corresponding variations in the magnetization of the soft iron core around which it circulates, and simultaneously sets up currents by voltaic induction in the surrounding secondary coil and main circuit.

But the very fact that the magnetic condition of the core is thus altered, implies still another step. This variation in magnetism reacts, and tends also to set up induced currents in the secondary helix, and these being uniform in direction with the currents induced in the same coil directly from the primary current are superadded thereto, and the two constitute the sum total of the electrical excitement in the secondary helix.

As a matter of fact either one of these two sources of the alternating secondary currents is sufficient when associated with a telephone transmitter to produce a fair power, even when the induction coil is of ordinary form. It has, however, been experimentally demonstrated that the varying magnetism of the core exerts a much greater influence over the secondary helix than is exerted by the varying primary current; and this notwithstanding the said influence must necessarily be exerted through the several layers of the primary coil; we are thus brought face to face with the inference that the application of the induction coil to a battery transmitter is (at any rate in a great measure) practically a return to the magneto transmitter, but operated upon a plan by which we are enabled to effect more radical or accentuated changes in the magnetic field.

The core of the inductorium corresponds to the soft iron pole-piece of the permanent magnet in the magneto telephone; the primary coil with the constant battery current flowing therein is the equivalent of the permanent magnet itself; and the secondary coil, corresponds to the short electro-magnetic helix used in the magneto telephone.

Thus we see that the real advance which we have made, amounts to this :—

Instead of developing the talking currents, by vibrating a diaphragm in front of a polarized core, surrounded by a coil of insulated wire in the line circuit, they are developed by vibrating a diaphragm in such a way as to vary the strength of a constant current of electricity surrounding and originally exciting the polarized core, the line coil in this case being in turn wound upon the exterior of the exciting circuit and current upon the same core.

Or, to state the matter differently, in the first case the secondary currents are set up by causing the armature to alternately approach and recede from the field magnet; while in the second case they are set up by varying the intensity of magnetization of the field magnets. This view of the operation of the induction coil in the transmitter indicates then, that it amounts but to a second and perhaps superior mode of varying the magnetism of a core, and of thereby setting up the telephonic currents in the main line helix.

And when this view of the operation is studied the absolute identity of this method with that employed in the use of the ordinary magneto transmitters is more clearly recognized; and we are enabled to perceive plainly that both, though differing in detail, are equally with one another "the method of and apparatus for transmitting vocal or other sounds telegraphically, as by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sounds." A careful consideration of the ideas expressed above, will show the identity of the operation of the battery transmitter when associated with an induction coil, with that of the magneto telephone when operating as a receiver; since in both the strength of a magnetic core is varied by the passage of a current in or through a surrounding helix: this variation being utilized in the first case to excite secondary currents in a helix forming a part of the main line, and in the second case to vary the attraction exerted upon a vibrating plate.

The above theory of the operation of the induction coil in the battery telephone is well illustrated in the drawings which form a part of some of the earlier patents of Thomas A. Edison upon modifications of the telephone transmitter.

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Figure 9 is a reproduction of a diagram found in a patent issued to Mr. Edison on April 30, 1878, No. 203,013.

In this patent a transmitter, which operates by cutting in or out a greater or less number of resistances in accordance with the vibrations of a diaphragm, D, is placed in circuit with a local battery, C, and a primary helix, P. A secondary helix, R, is included with a receiving telephone, A, in the

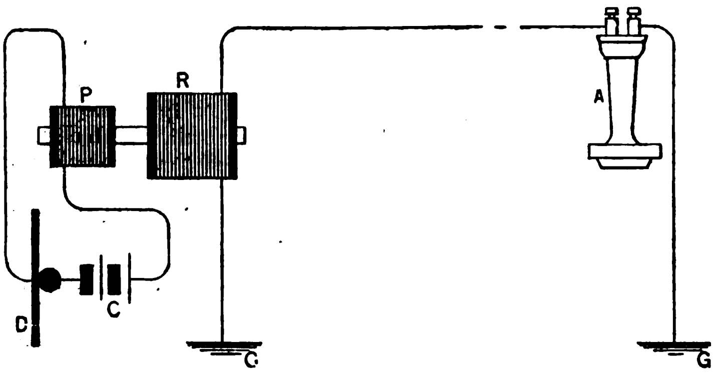

FIGURE 9.

main line circuit, one end of which is grounded at the home station, while the distant end is, of course, grounded also.

The peculiar feature of this system is, however, the construction of the induction coil, which is evidently based upon the theory of operation which I have described. The primary and secondary helices are both separately wound directly upon the opposite ends of the iron core. The primary is of coarse wire, and the secondary consists of a large amount of fine wire. It is obvious from the drawing that in a coil constructed upon this plan the office of the primary coil is both to develop and to vary the magnetism of the core; and that the function of the secondary coil is to develop the telephonic line currents in consequence of and in correspondence with the said magnetic variations.

It is true that by adopting such a construction we are unable to avail ourselves of the additional power due to the voltaic induction of one helix upon the other, but I am convinced from the success I have obtained with coils of similar construction that this is more than counterbalanced by the removal of the restrictions which are necessarily placed upon the primary coil by its position between the secondary coil and core. By isolating it, as in the drawing, we can wind it to a high electro-magnetic power.

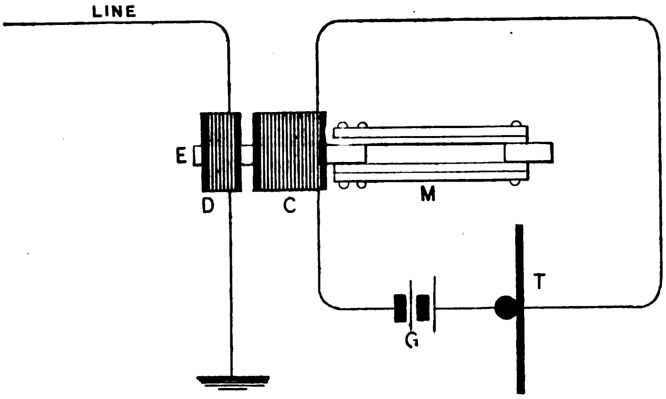

FIGURE 10.

In practice it would be a better plan to make the secondary coil smaller and flatter, and to bring it as near to the pole as possible. The primary helix could then be made to cover the greater part of the core so as to exercise a powerful effect thereupon.

[1] It is a well-known fact in electrical science that if the soft iron core of an electro-magnet can by any means be maintained in a state of permanent magnetic polarization, it will be much more susceptible to variations under electrical vibrations of given strength than it would be if in a neutral or non-polarized condition.

It is thought that the reason of this is the condition of unstable equilibrium in which the molecules of the core are placed, and which enable them to be much more easily affected either way than when in their normal or non-polarized condition.

Such a condition may be attained in a variety of ways. The plan shown in figure 9 is one in which the primary coil and local battery perform the office of magnetization; or a battery may be included in the main line circuit as in the first plan. If practicable, however, it seems to me that the best way is to magnetize it inductively by means of a strong steel permanent magnet. The local battery or primary coil which will still be retained for the purpose of varying the strength of the magnetism will thus be relieved from the work of producing the magnetism initially, and its entire energy can thus be utilized to effect the variations.

Figure 10 shows one form which might be employed if a bar magnet is used.

A soft iron core, E, is attached to a permanent magnet, M, and the permanent magnetism which it thus, by induction, acquires, is varied by the action of the primary coil C when influenced by the transmitter T and battery G. These changes in the magnetism then excite secondary or induced currents in the small coil D, which is in the line circuit.

A still better form would be that of a horse shoe. Let a suitable steel horse shoe magnet be made (compound or otherwise), and let each leg be provided with a soft iron pole-piece as in the cuts, figures 11 and 12.

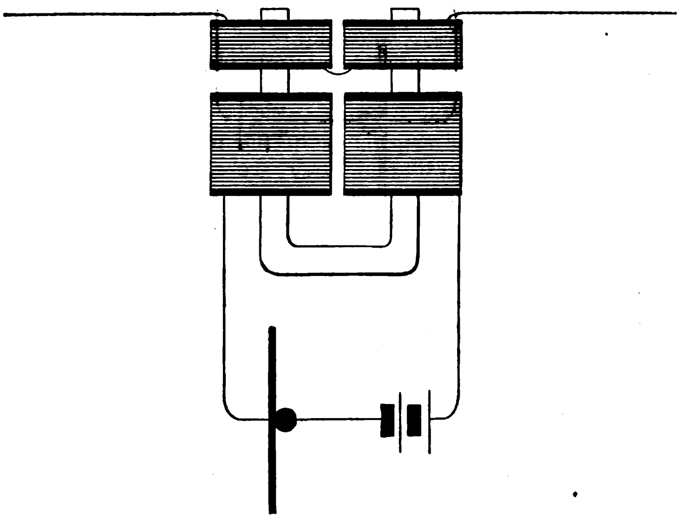

FIGURE 11.

The secondary coils are then placed on both pole-pieces, and the primary coils or electro magnets may either be placed one on each leg, as in figure 11, or a larger one may be wound on the bend of the magnet, as in figure 12.

It has been ascertained by experiment that the currents induced in a secondary coil by a primary and core arranged after this fashion are in any case of very considerable strength, but it is also found that their strength is increased nearly 25 per cent. upon the application of a soft iron bar armature, which has been carefully deprived of residual magnetism to the poles, as in figure 13.

A consideration of these results has suggested that the telephonic transmitter induction coil of the future may be based upon these principles, and there seems to be very

1. Vide deposition of F. L. Pope in suit of Bell Telephone Co. *vs.* Dowd, *et al.*

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strong evidence that an induction coil having a permanently magnetic horse shoe core, and fitted with a magnetism varying primary helix, in which is included the local battery and the variable resistance transmitter; and with a horse shoe armature consisting of a separate electro-magnet, a permanent magnet with soft iron cores, or a soft

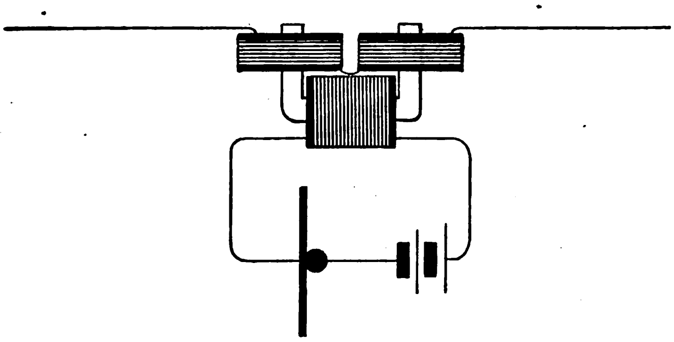

FIGURE 12.

iron horse shoe magnet, magnetized only by contact with the primary magnet, having a secondary coil on each leg near the end will be one of the most successful forms.

If this armature be either permanently or temporarily magnetic, its south pole should be brought into contact with the north pole of the primary magnet.

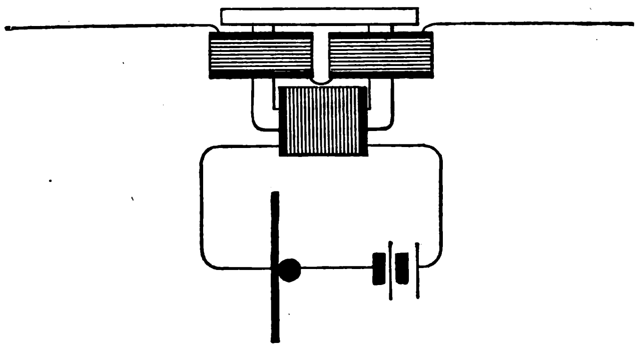

FIGURE 13.

It may add to the total effect in the secondary coils which are included in the line circuit, to place in addition to the two on the legs of the armature two others, one on each leg of the primary magnet. These may be connected either in series or in multiple arc together. In any case, irrespective of the form of coil, it has been found that the strength of the induced currents is quite superior when, what for want of a better term, we may call a closed magnetic circuit, is made; the two ends or poles of the iron core being connected, and the secondary coils being caused to surround the same near the poles.

THE SELF-INDUCTION OF AN ELECTRIC CURRENT IN RELATION TO THE NATURE AND FORM OF ITS CONDUCTOR.

AT an ordinary general meeting of the Society of Telegraph Engineers and Electricians, February 11, the discussion of Professor Hughes's paper[1] was opened by Lord Rayleigh, who pointed out that Professor Hughes did not use the term "self-induction" in the sense which Clerk Maxwell and others employed it. The term could be expressed as a definite quantity which was independent of the metal experimented on, except in the case of magnetic metals. The element of resistance enters into the question, so that if we call L the self-induction, R the resistance, and T_1 time, then we have

$$\frac{L}{R} = T.$$

The quantity T had been called by him the "time constant." The method of measuring self-induction suggested by Clerk Maxwell was that of obtaining stable balance on a Wheatstone bridge, one arm of which contained the resistance whose self-induction was required, and then making and breaking the battery circuit and observing the throw of the galvanometer needle; the value of the galvanometer constant was observed by obtaining a small permanent deflection. The magnitude of the electromotive impulse when contact was made depended upon the coefficient of induction, and also upon the current. He doubted whether in Professor Hughes's method the two quantities were sufficiently separated. No ambiguity would arise provided the wire dealt with had all the same resistance. Maxwell gives two methods of measuring self-induction, but those methods are probably not applicable to Professor Hughes's apparatus. In Maxwell's book the case of two long parallel conductors was dealt with, an equation of the form

$$\frac{L}{l} = 2\mu_0 \log. \frac{b_2}{a_1\, a_1'} + \frac{1}{2}\mu + \frac{1}{2}\mu'$$

being obtained. In this equation a_1 and a_1' were the respective radii of the wires, μ_0 the magnetic permeability of the air, b the distance between the centres of the wires, and μ and μ_1 the magnetic permeability of the wires themselves. The latter quantities are very high numbers in the case of magnetic metals. He would point out that the quantity, log. $\frac{b^2}{a_1\, a^{1'}}$, was not correct unless μ and μ_1 were equal. Professor Hughes by his experiments brings out the fact that, in the case of iron, the division of the flat ribbon into strips did not make any difference in the effect, but in the case of copper it does; this is perfectly in accordance with the equation of Clerk Maxwell. The formula before mentioned became considerably modified if the wires were close to each other, as then the mutual reaction came into play; this point Maxwell had not dealt with. In the case of two concentric tubes the problem became more easy, and if the space between the tubes was very small, the cylinders of the same material, and also if the cylinders were very thin as compared with their radii, then calling r the common radius and c the thickness, the total section of each ring would be $\pi\ c^2$, and the equation of self-induction would be

$$\frac{L}{l} = \frac{2\ \mu\ c_2}{3r^2}\left(1 + \frac{1}{10}\frac{c^4}{r^4} + \text{etc.}\right)$$

This equation shows that if c is preserved constant, then by increasing the radius *the self-induction may be reduced to any extent we please.* Maxwell in dealing with the problem recognized only two qualities, viz., magnetic permeability and resistance. The question raised by Professor Hughes's experiments is whether there is any effect other than that which is not caused by resistance alone. The carbon and metal results are curious, and the question arises whether the results obtained were in any way due to the form of the apparatus itself. As regards the effects observed with stranded iron wire, he rather thought that they were due to the strands being separated from each other by a stratum of air, the quantity μ_0, in fact, being very small. The results in the case of copper strand were difficult to understand; they might possibly be due to some facts not yet brought out, though he thought there was probably only a misunderstanding of *terms* and not a new fact discovered. Lightning conductors, it was pointed out, might either act to enable electricity to be discharged with facility or to prevent its

1. See p. 130, April issue, ELECTRICIAN AND ELECTRICAL ENGINEER.

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accumulation. Speaking of the action of the telephone, Lord Rayleigh stated that it had been argued that a certain amount of magnetism was necessary for proper action; this he did not find confirmed by his own experiments. Referring again to the constants μ, he pointed out that they only remained so as long as the point of saturation was not attained; after that point they became variables.

Mr. Frank L. Pope said it was 30 years since he entered the telegraph service; at that early period many phenomena were observed which could not then be accounted for. Some of these had subsequently been explained, but others only became evident as a consequence of Prof. Hughes's researches. The burning of coils by lightning, even when the line was earthed close to the coils, was now comprehensible. In the type printer of House, it was noticed that much better work was obtained on a stranded than on a solid wire, though, as far as could be judged at that period, the resistances must have been about equal; at the time the fact was put down to the supposition that the current flowed only over the *surface* of the wire. The observation that the coils of an electro-magnet, when joined up in multiple arc, gave a much higher speed in Wheatstone automatic instruments than when the same resistance of solid wire was used, was also explicable from Hughes's experiments. In 1876, an automatic system with a chemical recorder was worked over a 100-mile line at a rate of 1,000 words per minute; the wire used was a compound of copper and steel. The same speed could not be obtained over an iron wire; but it was not proved that a plain copper wire would not give equally good results, as the experiment had not yet been tried.

Prof. Forbes pointed out that the case of an earth wire being unable to protect the coils of a telegraph instrument had an analogy in the case of a gun bursting when fired if the muzzle were loosely plugged with snow. The influence of an iron sheathing round a conductor might lead to important modification in the construction of submarine telegraph cables, thus the use of a sheathing of gun metal might enable the working speed to be increased. The self-induction of an Atlantic cable, he pointed out, was enormous. The remark of Lord Rayleigh that all the results obtained by Prof. Hughes had been foreshadowed by Clerk Maxwell, was, he thought, rather hard, as a careful going into the matter would, he was of opinion, reveal that there was more in the experiments than at first sight might be imagined. He considered that the question of the coefficient of self-induction was not the only point to be dealt with, and that new facts had really been discovered. Lord Rayleigh had said that on stable equilibrium being produced, then when induction causes this to be out, a new balance can be obtained. Now, as a matter of fact, this new balance would be different for making and for breaking contact; but Hughes gets a balance which is the same for both. Maxwell's results are not in harmony with those of Hughes. In the case of wires of different thicknesses, the equation for the induction is

$$L = L_1 \frac{d\,c}{d\,t};$$

but for a strip we have

$$L = R\,C + a\frac{d\,c}{d\,t} + b\frac{d^2\,c}{d\,t^2}.$$

When the two last terms are equal to o, then we have the condition for stable equilibrium. The self-induction in the middle of a strip is greater than it is at the edges, and this is still more marked in the case of a cylinder; so that a current circulates in the wire, the direction of which is reversed when the circuit is broken. This consideration completely explains all the phenomena obtained by Hughes. Seventeen facts mentioned in the paper are thus accounted for.

Dr. Hopkinson said that with regard to methods of measuring self-induction, he had suggested one which was a modification of that of Clerk Maxwell, two galvanometers being used, one of which was in the battery circuit. Prof. Forbes had touched upon the distribution of currents in conductors when self-induction takes place; when a current is put on this distribution is not uniform, but changes from the centre to the circumference of the wire or strip. The question of round *versus* flat lightning conductors had, he thought, been completely settled by the experiments of Hughes.

The discussion was then adjourned.

The following reply to the above discussion has since been published by Professor Hughes:

Lord Rayleigh, while fully recognizing the importance of the subject of my researches, seems not to have seized all the details of the method which I have employed, or the meaning of some of the terms which I have used. Prof. Forbes has already replied to that portion of his remarks; but in his communication dated February 24th, Lord Rayleigh assumes that "the disturbance depends upon the rapidity of vibration, so that, in the case of ordinary mixed sounds, silence can be attained only approximately." Prof. Silvanus Thompson has also asked me if the results depend on the rapidity of the contacts. In reply, I must state that in point of fact the rapidity of the contacts have no influence on the result, providing they are not more rapid than the rise and fall of the extra currents.

Let us suppose that, instead of rapid contacts, we make and break the contact once only per minute, then, on making or breaking the contact, we shall hear a single blow or tap on the telephone; and if the communications of the bridge and telephone are arranged for the *stable* period, this sound will not be heard when the resistance of the bridge is perfectly adjusted. Suppose that we now change the communications so as to observe the *variable* period, still making and breaking contact but once per minute, we shall then find (if there is self induction taking place in the wire under observation) that we have no longer silence at the previous adjustment of the bridge; if this disturbance is due only to the extra currents, we can reduce it to zero by throwing in from the sonometer an opposite momentary secondary current of *equal* value; but if the disturbance is due only to the resistance being changed, then we shall have to move the slide on the bridge until we have again perfect silence. In many cases we have to deal only with the extra currents, in others there is a far greater change in the resistance of the wire than in the force of the extra currents. Both can be adjusted separately or alone, but no change of the resistance slide will compensate for the induced currents, nor will any change of the sonometer affect in the slightest degree the required adjustment of the resistance slide; it is the first portion of the current that we are measuring by means of the telephone, or its action at the moment of making or breaking contact.

The object of my researches was to observe what takes place at the first instant of contact. To this the telephone responds with admirable precision, whereas, as I have already said, a galvanometer would be useless for such delicate experiments as I have made, where it is necessary that the self-induction of a few inches of straight wire may be readily perceived and accurately measured. The rate of speed of contacts, therefore, can be increased up to the point where the duration of the contacts is at least as long as the duration of the extra currents. In short wires the duration in time of the extra currents is exceedingly small, and much less than any duration of contact that I have used; a large electro-magnet would require a lengthened contact and a different method. The only advantage, therefore, of short contacts is the constant repetition of sounds or beats, enabling us the more readily and rapidly to find the required balance.

All of the important points mentioned in my paper have been verified by independent methods, and they have also

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been repeated with slow and rapid contacts, as well as with widely different external resistance in the battery circuit; but I wish to show that the induction bridge gives perfectly reliable results, and that its readings can never be changed or misunderstood.

I have chosen a fine german-silver wire for the resistance bridge, because german silver has (even in the form of large wires) an extremely low inductive capacity; and this, when the wire is fine, is again reduced to a mere fraction as compared with what it would be in wires of 1 millimetre diameter of different metals. To test the instrument, place a piece of similar sized german-silver wire in the arm, A B, we do not then find any trace of self-induction, as all the four arms of the bridge are equal; we may vary its resistance by shortening the length of the wire, but the bridge can only then be adjusted to zero by moving the resistance slide. Under these conditions there is no difference perceived between the stable and the variable period, as the changes produced are equal on all sides. Let us now replace this german-silver wire between A and B by a copper wire of the same resistance, we then find that the stable period gives exactly the same zero as previously, but that a disturbance takes place in the *variable* period, and that this cannot be adjusted by the *resistance* slide, but that it is completely reduced to zero by the opposed induction current of the sonometer. Again, if we heat this same wire, its resistance is changed, and can only be compensated by moving the resistance slide; if we make this wire into a loop or a parallel return, there is no change in the resistance, but the *self-induction is reduced* at once, as shown by the sonometer; winding this wire in a coil increases the induction, and, within certain limits, we may perceive no change in its resistance, whilst its *self-induction has increased* several hundred per cent. Now, suppose we increase the resistance by heating and the induction by coiling the wire, we have then two distinct effects of known values, and the measurements given by the resistance slide and by the sonometer are precisely those which would have been given by either when measuring them separately; and this again proves that where we have a case of change of resistance it can only be met by adjusting the resistance slide, and where we are measuring the electromotive force of the extra currents they can only be compensated for by the use of the sonometer.

The cause of the extra or momentary increased resistance of a wire during the variable period can be explained. The current, on entering the wire, produces an extra current of an opposite name, and that this really opposes the passage of the current is proved by the upsetting of the previously balanced bridge; there is, in fact, in this moment less resistance on the opposite side, and the balance can only be restored by the resistance slide.

There are, however, cases where this effect is entirely reversed, in which there is less resistance in the variable than in the stable period; this occurs when we are testing extremely fine wires with powerful currents, for the steady current heats the wire, thus introducing an extra resistance, which does not take place to the same degree with short contacts as in the variable period; but, as I have already said, care must of course be taken to avoid all such sources of error; and if we understand the subject, and know exactly where to look for errors, there should be no difficulty in constructing a bridge perfectly free from experimental error.

The instrument and method which I have employed have a great advantage over any previously used, as from the exquisite sensibility of the former we are enabled, not only to verify all the results obtained by previous observers from their experiments on coils, but to do that which no other instrument or method has previously enabled us to accomplish, viz., to observe the self-induction of straight wires and the laws of its reactions (as in the contiguous portion of the same current in straight wires and sheets) entirely separate and distinct from the mutual reactions of one part of a coil upon another. These I have shown to be quite different, as an iron coil has less self-induction than a copper one, whilst in straight wires the reverse is the case. We must not neglect this all important point, for in no way do my researches contradict well-known results, they simply go further, and show the physical reasons for certain phenomena; and where theory has failed to predict, or previous experiments to show, this has been due simply to the fact that no instrument existed sensitive enough to record or measure the effects which take place in the self-induction of a comparatively short wire free from external reaction.

Self-induction in coils has been a subject which I had of necessity to study in relation to my printing telegraph instrument. The movement of my armature being extremely rapid, produced extra currents of sufficient force to trouble other instruments on the same line. I finally vanquished this difficulty in 1860 by an arrangement whereby the armature, in rising, instantly short-circuits its own electro-magnet, and by mechanical means (peculiar to the instrument) is entirely separated from the line, placing the line at the same time direct to earth or battery, but leaving the electro-magnet open, so that the return of the armature produces no extra currents that can affect the magnet or line. This has answered perfectly, and has been in use on all of my instruments since 1860 up to the present day. I have also used, since 1861, divided coils, whereby the current is passed through both coils in parallel, and not in series; this I use on lines less than 500 miles, not simply because of the diminished resistance, but because I found from experiments much less disturbing influence from the extra currents. I have, however, lately by the aid of the induction bridge, been not only enabled to measure this difference, but to trace it to its true cause, and the following table gives a representative result obtained from numerous coils of different sizes and resistances, and with or without iron cores:—

Coils formed of 3 metres silk-covered copper wire, 1 mm. in diameter, each coil being 3 centimetres diameter.	Comparative force of the extra-currents.
One coil alone	100
Two similar coils in series	174
Two similar coils in parallel, but separated 5 cm. from each other	55
Same two coils in parallel, but superposed	81
One single coil of thicker wire of exactly the same form, length, and resistance as the two coils in parallel	75

The table shows an increase of force when two coils are in series, but not quite double, as a portion is reduced by the increased or added resistance. This is a well-known effect; but an interesting result is shown where the two coils are parallel and separated, giving them 32 per cent. less induction than the same coils superposed, and also 26 per cent. less than that of a single coil of precisely the same resistance. We can easily explain this, and trace the effect to the reactions of contiguous coils on each other.

I have shown a remarkable difference in the inductive capacity of different metals when formed into wires of the same diameter: and as the order follows that of their respective specific resistances, it became an interesting study to know what would be the result if all the wires were of the same length and resistance. It is necessary to employ the same length, as the induction increases with the length: consequently, a copper wire, compared with a brass wire of equal resistance, and therefore of greater length, would show a great difference in their inductive capacities. There are, however, several methods, free from experimental errors, which I have employed in this investigation.

If we take wires of different non-magnetic metals of the same length and diameter, and reduce them to the same resistance by an added resistance comparatively free from induction, such as carbon, I find that there is apparently no difference whatever in the inductive capacity of the different metals, all (yet tried) giving by this method very

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nearly the same result; but in this case we have added an external resistance, and thus prevented any difference of action due to the different density of the current in metals of high and low resistance.

If, instead of an added external resistance, we take wires of the same length and resistance, but of different diameters, we then find a marked difference in their inductive capacities; for instance, a pure copper wire, compared with a brass wire of double the diameter, shows a marked higher force in the copper wire. We might naturally believe that the brass wire, from its larger diameter, would give higher results than the smaller copper wire; but if we have thoroughly seized the importance of the phenomenon which I have demonstrated of the reaction of contiguous portions of the current on each other, we can easily prove that the larger the diameter of the wire the less will be its proportionate reactions, so that, whilst the resistance decreases directly as the increase in section, the reactions of the currents upon each other become *less* as the diameter increases, the resistance diminishing as a straight line, whilst the induction would follow a curve similar to that shown in the diagram.

The following table shows the electromotive force of the extra currents on wires and strips 1 metre in length, a chemically pure copper wire of 1 mm. diameter being taken as the standard of 100, to which all the rest were compared :—

Wires of the same diameter, but of different resistance—1 metre in length.		*Wires* of the same resistance, but of different diameters—1 metre in length.	
Soft Swedish iron	500	Soft Swedish iron	400
Copper	100	Copper	100
Brass	65	Brass	88
Lead	50	Lead	81

Strips of the same width and thickness, but of different resistance—1 metre in length.		*Strips* of the same resistance and thickness, but of different widths—1 metre in length.		
12 mm. wide, $\frac{1}{10}$ mm. thick.		$\frac{1}{10}$ mm. thick.		
Copper	60	12 mm. wide	Copper	60
Brass	48	42 " "	Brass	45
Iron	45	72 " "	Iron	39
Lead	35	96 " "	Lead	29

In the above table, wires of the same diameter follow in the order of their resistance, iron alone being the exception; the same order is preserved in wires of the same resistance but of different diameters. In the latter case there is a nearer approach to equality, but they still show a difference of from 12 to 19 per cent., and whilst the non-magnetic metals have increased their inductive capacity with increased diameter, iron has fallen 20 per cent.; consequently, wires of different metals of the same resistance have not the same inductive capacity, owing, I believe, to the action of contiguous portions of the current, as I have already shown.

If we reduce the extra currents by employing thin sheets or strips, there is in the case of iron a still more remarkable difference, for in strips of different metals of the same width, the force of the extra currents in iron is actually less than that of brass, and if we compare an iron strip with an iron or copper wire of the same resistance, we have iron wire 500, copper wire 100, and the iron strip 45, or actually 55 per cent. less than the copper wire.

In the case of wires, a nearer approach to equality in inductive capacity is shown when they are of the same resistance, but in strips this is reversed, for here, when equality in resistance is produced by wider strips, the difference becomes greater, iron then having actually less inductive capacity than a lead wire of the same resistance.

This extraordinary result must be due, not only to the reactions of contiguous portions of the current being less in sheets or strips than in wires, but also from an imperfect formation of the circular magnetism which takes place in all iron wires on the passage of an electric current. This, however, is only a partial cause, as we can obtain a still further reduction of the extra currents by employing numerous fine wires separated from each other, the circular magnetism in the latter case being perfectly formed in each wire; but we still have the maximum experimental reduction due to the separated portions of the current no longer acting on each other. Copper and all metals show a similar reduction when we separate the wires of a strand conveying a current, but when the numerous wires are brought close together, copper approaches in value that of a solid wire, whilst iron wires are but comparatively little influenced by their closer proximity.

I have tried all forms of conductors, such as square, stellar, tubular, &c.; they all show a gradual diminution of inductive capacity as compared with those of a solid circular section; in a solid conductor the maximum effect being obtained in the circular section, and the minimum in that of a wide flat sheet.

We can reduce the self-induction of any metal far below the comparative force that I have given, by widening the strip or, still better, by diminishing its thickness as we widen it, and it is evident that if we keep the same width, and gradually increase its thickness, we then approach the conditions of a solid wire; consequently, where it is necessary that we should be able to utilize a given amount of copper in the best possible form, so as to convey a current of an enormously high tension but of short duration, as required in a lightning rod, we should widen the conductor as much as the mechanical stability and durability of the conductor will allow, and I believe that a lightning conductor of copper 1 mm. thick by 10 cm. wide would satisfy the mechanical requirements whilst preserving the physical conditions necessary for a perfect conductor.

My experiments have shown clearly that a solid iron rod is unsuitable for a lightning conductor; but we may use a stranded iron wire or a flat iron sheet of the same conductivity as the copper. The iron wires should be galvanized, as all iron wires coated with a non-magnetic metal show a marked reduction in their inductive capacity; and here, as well as in the ribbon form of copper conductors, practice has guided our inventors in the right path, for it is an almost universal practice to galvanize iron wires in order to preserve them, and ribbon copper lightning conductors have been gradually replacing the most objectionable iron rod, for which there can be no defense based on experimental or scientific reasoning.

I have already given the results of a compound wire of copper and iron made by myself, but I have since (through the kindness of Mr. W. H. Preece) been furnished with some most admirable specimens of American compound wires, the copper being electro-deposited upon a core of steel wire, and also some specimens in which the core is of copper with a steel exterior. I have thus been enabled, not only to verify my previous results, but to prove that an exterior coating of copper has a most powerful influence in reducing the self-induction of its steel or iron core; for, if we take a given length of this wire and compare it with a similar length and diameter of copper wire, and taking for comparison the copper as a standard of 100, we have only 107, or 7 per cent. increase, for the compound wire, but if we file off the copper so as to leave the steel core bare, the inductive value of this same wire rises to 350.

In order to study this effect, let us place an iron wire in the interior of a closely fitting copper tube, and insulated from it: this has no effect upon the iron wire; but if we join the exterior copper tube to the interior iron wire at both ends, the current passes through both at the same time, and the inductive capacity of this compound system is reduced almost to that of solid copper, as previously observed in the compound wires. These effects can be fully explained, when we reflect that the circular magnetism produced by the passage of an electric current through an iron wire is produced only upon the exterior portion of the wire, and cannot take place when this exterior is, as in

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a compound wire, of copper; consequently a steel or an iron wire coated with copper of sufficient thickness, is entirely free from this magnetic reaction.

Now, if an exterior coating of copper has such an effect in reducing the self-induction of its iron core, it follows that an opposite effect should be produced by coating a copper wire with iron. Experiments with this, and also with a copper wire inserted in a closely fitting iron gas tube, prove that the effect was as foreseen, viz., a remarkable increase in the inductive capacity of the wire.

One result, however, which I did not foresee, although it is clearly indicated in the experiments quoted in my paper, is that not only is the inductive capacity of the interior copper wire increased to a great degree, but that a copper wire coated with iron has a higher degree of self-induction than a solid iron wire; in fact, its inductive capacity is not only higher than is possible to obtain from the softest iron wire, but its *resistance in the variable period* is proportionately greater than any yet remarked in a solid iron wire. I have made numerous experiments on this subject, and they all show that whilst copper in a straight wire or a single *wide* loop has a far less inductive capacity than iron, it has, on the other hand, the property of being far more excited by the reaction of iron, so that a straight copper wire can be excited by this reaction to a degree greatly exceeding that of a straight iron wire under precisely the same conditions.

I will cite a few experiments which illustrate this point. A copper and an iron wire of equal resistance, and 1 metre in length, were measured for their inductive capacity and resistance, the inductive capacity of the copper wire being as 100, as compared with 400 for the iron. The resistance of the copper in the variable period had only 8 per cent. increase, compared with 128 per cent. for the iron; but a great change took place when each of these was placed in the interior of an iron gas tube of sufficient diameter to allow of the wire being insulated. The force of the extra currents in the copper wire then increased 350 per cent., whilst the iron increased but 8 per cent.; the force of the extra currents being now for copper 450, against 433 for the iron.

The influence of an exterior iron tube on the resistance of the wire during the *variable* period was still more marked. The copper wire, which without the exterior iron tube had only 8 per cent. increase, now showed 934 per cent. increase, or, by direct measurement, 1 metre of this wire, during the rapid rise and fall of the current as in the variable period, had precisely the same resistance as 10.34 metres in the stable period, or a much greater difference than I have obtained from an iron wire; for the iron wire insulated in the gas tube only showed an increase due to this tube of 22 per cent., giving a total of 178 per cent. difference, or, by direct measurement, 1 metre of the iron wire with its insulated iron sheath, in the variable period, requiring 2.78 metres to balance it in the stable period; thus copper shows more than three times the sensibility to an exterior sheath of iron than an iron wire itself. Iron appears to be self-contained, and, as regards self-induction, comparatively less acted on by an exterior influence. This is well shown in the case of coils, where the induction of a coil of insulated iron wire is but slightly increased by its own reactions, or those produced by the introduction of an iron core, as in an electro-magnet, whilst copper coils with an iron core show a remarkable increase. We can thus easily obtain extra currents of ten times the electromotive force of those from an iron coil of the same length, resistance or diameter; and the resistance of a copper coil, which in the stable period may be far less than that of an iron coil, can, by means of its increased self-induction from the reaction of its iron core, be greater than that of an iron wire coil. At first glance this may be considered unfavorable for copper; but we must remember that whilst copper, in the presence of iron, can be excited to a far higher degree than iron, and consequently has stronger extra currents and greater proportional increased resistance in the variable period, this is really a measure of the work it is capable of doing, for we are able by means of this property to obtain the high efficiency of transformation of energy as in the secondary currents. In point of fact, a dynamo machine having its electro-magnet and armature wound with insulated iron wire would, irrespective of its resistance, have an extremely low efficiency as compared with those wound with copper; and as regards the resistance of either of these wires, there can be no doubt that the resistance of the armature of a dynamo, or, in fact, of any coil of wire as measured during the stable period, gives no approximate indication of what its *real* resistance is during the period in which it is doing work.

The following table shows the influence of an iron tube surrounding a straight iron or copper wire, compared with compound wires:

Wires and iron tube each 1 metre in length.	Comparative electromotive force of the extra currents.	Approximate comparative increased resistance during the variable period (that of the stable period being taken as 1).
Copper wire, 2 mm. diameter, alone	100	1.08
Same wire insulated in the interior of the iron tube	450	10.34
Same joined to the tube at both ends	275	10.00
Same in contact with the tube throughout its length	200	7.83
Compound wire (copper interior with steel exterior)	325	4.35
Soft Swedish iron, 2 mm. diameter, alone	400	2.28
Same wire insulated in the interior of the iron tube	433	2.78
Same joined to the tube at both ends	240	2.70
Same in contact with the tube throughout its length	215	2.60
Compound wire (steel interior, copper exterior)	107	1.20

The table shows that the iron tube has a much greater effect upon the copper wire than on the iron wire, the effect in both cases being at its maximum when the tube is insulated from its central conducting wire, for when the wire is in contact with its tube there is evidently a shunt action, or species of eddy current, formed between the outer coating and the central portion. This I have been enabled to measure by interposing the telephone between the inner core and the sheath, or still better, by employing a double insulated sheath of iron or copper, and joining them together at one extremity, the opposite ends being joined through the telephone; by this means we are enabled to measure the differential effects of the secondary currents generated in an inner and in an outer sheath.

The table also shows the effect of joining the outer sheath at both extremities, thus allowing a true eddy current to form; this at once reduces the electromotive force of the extra currents, but has but little effect on the differential resistance in the variable period. If, however, we place the wire in contact throughout, so that the effect from the centre to the exterior of each portion can at once be partially neutralized, then there is a marked decrease in its resistance; and if, as in a compound wire, the exterior coating is in direct and still more intimate contact with the inner core, we then have the maximum reduction. We can thus prove that the shunt effect, or partial neutralization of the extra currents, takes place locally, and probably transversely. We see also, by its effect on the reduction of the resistance during the variable period, that the passage of an electrical current then takes place with less opposing resistance from the self-induction than could be the case if there were no internal partial neutralization

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of the extra currents. No doubt this effect also occurs in sheets and strips, and has its influence in causing the remarkable reduction of self-induction that I have already shown.

In conclusion, I once more desire to express my thanks to all who have taken part in the most interesting discussion that has followed the reading of my paper. Mr. W. H. Preece and Prof. Forbes, who have seen my experiments, have borne testimony to the truth and care with which I have carried out these researches; and our well-known American electrician, Mr. Frank L. Pope, has cited examples showing that the superiority of a stranded iron wire was noticed even in the early days of telegraphy, and that the superiority of a compound wire over an ordinary iron wire is a well-known practical fact in the United States. He has also cited a case similar to the experiments of Prof. Guillemin and myself, where an electro-magnet was destroyed by lightning, notwithstanding that the telegraph line was joined direct to earth in advance of the electro-magnet. I am glad that many of the results of my researches are fully borne out by the practical experience of the past; and I hope that those which have as yet not been foreseen in theory or applied in practice will receive the same attention and verification that all discoveries should undergo, as I feel convinced that their truth will become more and more evident when repeated in the laboratory or applied in practice.

PRACTICAL DYNAMO BUILDING FOR AMATEURS.[1]

(Continued from page 168.)

WINDING.

BEFORE dealing with the subject of winding the armature in question, it will be well to consider for what purpose the dynamo is required, whether for arc lighting, incandescent lamps, or for charging accumulators. For the first case, if it be required to work two arc lamps in "series," the E. M. F. at the terminal must be 110 volts, and the current flowing through the total resistance of the electrical circuit nine ampères, showing that this total resistance R by Ohm's law, thus, $R = E/C$, is equal to the quotient obtained by dividing the electromotive force in volts E by the current in ampères C, therefore, $110/9 = 12.2$ ohms. The resistance R includes the resistance of arc, series coil, or solenoid upon the lamp, leads, and the resistance of the armature between the brushes. In the cases of "series" or "shunt"-wound field magnets, this effective resistance R is increased or diminished respectively; but that must be dealt with in due time. Therefore, in considering the winding of the armature, the external known resistance must be taken, R, and the resistance of the dynamo r approximated, as it is yet unknown. Then, from the equation, $C \times R + r = E$, the required electromotive force is known, and must be provided for by a certain length of insulated wire, to be wrapped upon the core.

The electromotive force of any machine depends upon—

1. The strength of the magnetic field.
2. The rate of speed at which the conductor passes through the field.
3. The length of such conductor.

Now, the former may be varied by suitable arrangement of the field-magnets; they may be more massive and possess larger coils in one case than in another, or in fact, when the cores of the field-magnets are made of wrought iron, the efficiency of the magnetic field, in comparison with the current energy absorbed by its maintenance, is from 20 to 30 per cent. greater than is the case with a cast-iron field. Such wrought-iron cores and pole-pieces are, however, very difficult of construction without proper tools and contrivances, which are beyond the reach of most amateurs; but for the especial benefit of those who desire to profit by the increased efficiency of wrought iron cores, we shall afterwards describe such a set of field-magnets to suit the present form of armature.

1. From the *English Mechanic.*

The rate of speed at which the conductor passes through the field is dependent alike upon the diameter of the armature and the speed at which its spindle is driven.

The length of the conductor per volt of electromotive force varies according to the conditions enumerated above; recent improvements in dynamo machines by the best makers have limited it to three-quarter yard per volt.

Such machines, however, are not practicable for amateur construction; for advantage is taken of the fact that the nearer the iron core of the armature can be brought to the poles the greater the efficiency. Since this entails a large diameter, and corresponding field magnets, in order to get the requisite length of conductor in as few layers as possible, a certain loss of efficiency per weight of copper is unavoidable.

We must establish a length of wire per volt that will give the required effect upon this and similar dynamos; this deduced from actual experience in the construction of several machines of this type, of different sizes and output, all of which have given the calculated E. M. F. and current through the stipulated resistance, when worked. This length may be stated as three yards per volt, or its speed equivalent in the present instance 5,850 yards per second; giving a speed of 1,300 per minute, which is not excessive for a small machine.

Then, returning to the calculation of winding for 110 volts and nine ampères, through a total R of 12.2 ohms, the length of wire required for the armature conductor will be $110 \times 3 = 330$ yards, and since the commutator is to have 48 or 36 divisions or plates, preferably the former; $330/48 = 6.8$ is the number of yards in each coil.

A circle, $A\ B\ C\ D$, should now be drawn upon paper, figure 7, equal in diameter to the taped armature core, with an inner circle $E\ F\ G\ H$ corresponding to the centres of the stud holes. The latter being divided into six parts, the six ferrules should be lined out thereon, as small circles $a\ a\ a\ a\ a\ a$. An outer circle, $\frac{1}{8}$ inch less in diameter than the bore of the pole pieces, will represent the extreme diameter of the wire when wound. Radial lines $b'\ b'\ b\ b$ will indicate the spaces $c\ c\ c$ which are left in the winding by reason of the projecting ferrules. Between these draw the lines $d\ e$, which equals $\frac{1}{48}$ of the circumference of the armature, less the spaces $c\ c\ c\ c$, and between these the wire may be plotted out, and the number of layers deep and wide per coil ascertained. The length of wire that will pass closely around the iron core will represent the "least perimeter," and the length that would form the outermost coil, the "greatest perimeter," respectively 10.75 in. and 14.25 in., the mean perimeter being, therefore, $14.25 + 10.75/2 = 12.5$ in.

Now, by taking the external diameter of No. 16 B. W. G. cotton covered copper wire, and plotting it out within the space $d\ e$, it will be seen that four layers deep and five wide can be easily wound, even with the characteristic slack winding of the amateur.

Then $5 \times 4 = 20$ (No. of turns).
$20 \times 12.5 = 250$ (inches per division).
$250 \times 48 = 12{,}000$ (inches per armature).
$\frac{12{,}000}{36} = 333$ (yards per armature).
$\frac{333}{3} = 111$ volts (per 1,300 revs).

Which is near enough in all reason.

The next subject to be considered is the resistance of this conductor and its proportion to the external system, remembering that—

$$\frac{R}{r} = \frac{\text{work}}{\text{waste}} = \text{efficiency}.$$

Therefore it is highly important that r should be kept as low as possible.

The armature is divided, when running, into two portions, by the brushes upon the commutator, hence half only of the total length should be taken in the calculation. A reference to the column A in the following table will

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provide a multiplier for ascertaining the resistance of the length of conductor.

RESISTANCE PER YARD.

B. W. G.	A.	B. W. G.	A.	B. W. G.	A.
7	.0009	16	.0073	25	.077
8	.0011	17	.0092	26	.098
9	.0014	18	.0128	27	.120
10	.0017	19	.0175	28	.158
11	.0021	20	.0262	29	.188
12	.0026	21	.0302	30	.215
13	.0034	22	.039	32	.310
14	.0049	23	.049	34	.341
15	.0052	24	.063	36	.492

The resistance per yard of No. 16 B. W. G. is here shown to be 0.0073 ohm, therefore, half the length of the conductor $333/2 = 166.6$ yards, and $166.6 \times 0.0073 = 1.2$ ohms.

There is an apparent increase in running that appears to be proportional to the speed, and is due to the "self-induction" of the armature, as well as the inevitable rise in temperature when work is being done. In the present example actual test has shown its value to be approximately 12 per cent. of the resistance when cold. Using this value, the resistance to be calculated is $1.2 \times 12/100 = 0.14$ and $0.14 + 1.34$ ohms.

Following out the calculation, we must deduct this resistance from the total R of 12.5 ohms, and thus obtain the true external resistance—viz., $12.5 - 1.34 = 11.16$ ohms. From this data we can ascertain the proportion of work done in the armature and in the external circuit, the current now being $110 \dfrac{(E \text{ at terminals})}{11.16\ (R)} = 9.9$ ampères. Work done in armature $= C^2 r$ where C is the current in ampères, and r the resistance of armature in ohms; therefore, $9.9^2 \times 1.34 = 98 \times 1.34 = 131.3$ watts, and in the corresponding work in the external resistance r is $98 \times 11.16 = 1093$ watts; that is to say, that we absorb within the armature 12 per cent. of the total work, and the relation between useful work and waste at present stands thus—

$$\frac{\text{Useful work}}{\text{Waste}} = \frac{1093}{131} = \tfrac{1}{8} \text{ nearly.}$$

Now comes the question of the loss by reason of the energy absorbed in magnetizing the field magnets. Whether this be shunt or series, the result will be the same, since a given magnetic intensity must absorb a given amount of energy in producing it, either relying upon thick wire of low resistance, as in "series," or many turns of fine wire of high resistance, as in "shunt" wound fields. In the former case, the "ampère turns" are a given number, more current and fewer turns; and in the latter exactly the reverse. Say, for example, that 10,000 ampère turns will produce a magnetic field of a certain intensity; and in one example by 100 ampères flowing round 100 turns, and in the other by one ampère flowing round 10,000 turns, the magnetic effect is practically the same, and the energy absorbed in producing it also equal in both cases.

If the winding of the magnets is to be in "series," the resistance of the coils should be slightly less than that of the armature, in this winding, say, 1.1 ohms. Then the energy absorbed by the generation of magnetic intensity in the field will be $98 \times 1.1 = 107.8$ watts. But now the internal resistance of the dynamo is $1.34 + 1.1 = 2.44$, and the total energy expended in it, relatively to the useful work, may be expressed thus—

$$\frac{98 \times 2.44}{98 \times 11.16} = \frac{235 \text{ waste}}{1104 \text{ useful work.}}$$

and

$$\frac{235 \text{ waste}}{1339 \text{ total work}} = \tfrac{1}{5} \text{ approximately.}$$

Or, in other words, 20 per cent. of the total electrical work is absorbed by the machine.

It is worth while to compare the results obtained by winding the field in "series" with the relative "shunt" winding. The formula used in estimating the resistance in ohms of the shunt is as follows: $r_1^2/r_a = r_s$, where—

r_1 = external resistance
r_a = resistance of armature
r_s = resistance of shunt

Substituting the quantities known—

$$\frac{11.16^2}{1.34} = \frac{124.54}{1.34} = 92 \text{ ohms,}$$

actually reducing the effective external resistance, by providing two paths for the current. By the formula $R_1 \times r_s/R_1 + r_s = R$; where R_1 is equal to the external circuit and r_s to the shunt coils, the effective resistance R is obtained.

$$\frac{11.16 \times 92}{11.16 + 92} = \frac{1026.72}{103.16} = 9.96 \text{ ohms.}$$

say 10 ohms, then, according to Ohm's law, $E/R = C$, the total current flowing will be $110/10 = 11$ ampères, respectively 9.9 ampères through the external work, and 1.1 through the shunt.

Then,

$$\frac{1.1^2 \times 92}{9.9^2 \times 11.16} = \frac{110 \text{ watts expended shunt}}{1104 \text{ watts expended in external } R}$$

and comparing this result with the series winding, we get—

Shunt 110
Armature 131
241 watts expended in machine.

Waste 241
Total work ....1345 } shunt winding.

Waste 235
Total work ....1339 } series winding.

which is quite near enough to prove the values of the two methods, relative to the amount of energy absorbed in magnetizing the field.

Before going into the details of the somewhat tedious process of winding the armature, it will be well to consider the lengths and resistances of conductor and fields for other purposes, as before mentioned, such as direct incandescence lighting, and charging accumulators.

Let it be assumed that the taped armature and bare field magnets are to be wound so as to light 20 incandescence lamps of 38 ohms working resistance, commonly called 50 volt lamps, each absorbing a current of 1.3 ampères, and, of course, coupled in multiple arc ("or parallel").

The external resistance due to lamps. $\dfrac{38}{20} = 1.9$ ohms.

External resistance due to leads, &c., about 1-10th of lamps............ $\dfrac{1.9}{10} = 0.12$ ohms.

Total external $R = 2.09$ ohms.

And current required for each lamp $E/R = 50/38 = 1.3$ ampères, and for the whole circuit $1.3 \times 20 = 26$ ampères. Following this calculation in order to ascertain the E. M. F. required in the external circuit; again, by Ohm's law, $R \times C = E$ $2.09 \times 26 = 54.34$ volts. It must be borne in mind, when selecting a gauge of wire, that the current has a "heating" effect of 26 ampères in this case, and the wire must have sufficient area to conduct this without deteriorating the insulation, or greatly increasing its resistance by heat. The limit ought to be 2,000 ampères per square inch in machines of the construction that is here described.

In a well ventilated armature, where the mass of iron is in excess, and also laminated, and the field exceptionally

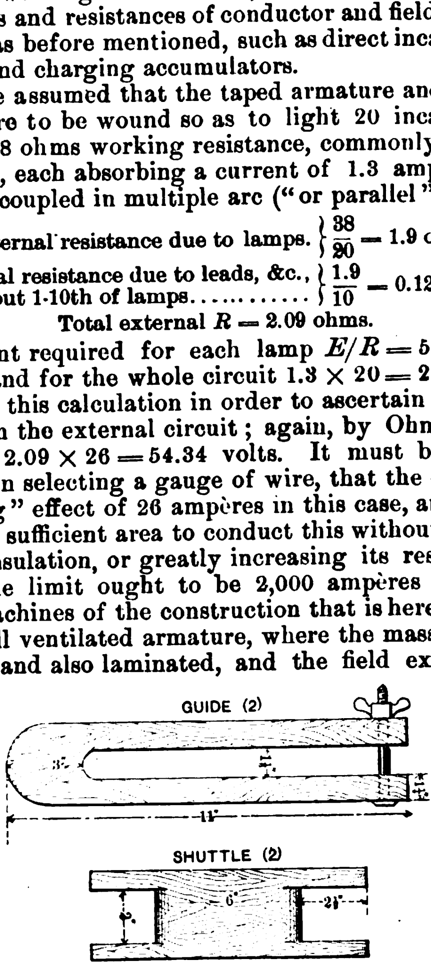

FIGURE 8.

powerful, there has been obtained a density of 2,570 ampères per square inch of conductor. Table II. gives a per-

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fectly safe and efficient ratio, and also allows for the conduction and radiation of heat from the core; in the present instance, this is very slight.

The table is suitable *only* for armature densities, since in the closed coil ring armatures there are really two circuits in multiple arc:

TABLE III.

B. W. G.	Diam. inches.	Safe current.	B. W. G.	Diam. inches.	Safe current.
6	.203	120	14	.083	21
7	.180	97	15	.072	17
8	.165	86	16	.065	12
9	.148	72	17	.058	9
10	.134	58	18	.049	7
11	.120	43	19	.042	5
12	.109	36	20	.035	4
13	.095	27	22	.028	3

This table is for ampères safe current per gauge, for *armatures* only.

From the table here given No. 13 gauge of wire seems best suited for the armature. The first column of diameters shows that 4 by 4 layers may be allowed per coil, and the mean length or perimeter is known, viz., 12.5 inches. The calculations previously given suffice as an example without again detailing the process, therefore:

$$\frac{12.5 \times 16 \times 48}{36} = 253 \text{ yards.}$$

and 253/3 = 82. volts at 1,300 revolutions per minute.

Upon referring to the resistance table, the running resistance of the armature will be 0.43 plus 0.09, the allowance for heating, induction, &c., before mentioned, total 0.52 ohm. The field resistance will be 0.4 ohm, and this brings the machine to 0.92, which, added to that of the external circuit, comes to a total of 3.01 ohms. Then, by Ohm's law, we again find the E. M. F. necessary to force 26 ampères through the work, $3.01 \times 26 = 78.26$ volts, showing that there is E. M. F. to spare, but which may easily be regulated by the speed.

Now, the ratio of the total work, and that expended in the machine, is

$$\frac{26^2 \times 0.92}{26^2 \times 3.01} = \frac{621.9}{2034.7} \text{ or } \tfrac{1}{3}.^*$$

The size and number of turns of wire upon the field magnets may be calculated from the data that will be supplied when the operation of winding them is described. A machine of this pattern, exactly similar in size and construction, was lately made to charge 27 E. P. S. accumulators with a current of 12 ampères, and to be driven by a 1½ h. p. gas engine, and since it has done good work the winding may serve as an illustration.

Gauge of wire on armature, 15 B. W. G.; length, 266 yards; running resistance between brushes, 0.88 ohm; E. M. F., 88 volts; shunt wound field magnets, 70 pound No. 18 B. W. G.; resistance, 35 ohms; exciting current, 2.5 ampères; speed, 1,250 revolutions per minute.

The "back E. M. F." of the accumulators is $27 \times 2.2 = 59$ volts; and as the E. M. F. at the terminals is 88 volts, it follows that $88 - 59 = 29$ volts is the actual available electromotive force to overcome the resistance of the armature, leads, and cells, which is $0.88 + 0.81 = 1.69$ ohm.

The peculiarity of this application of a shunt dynamo lies in this "back E. M. F.," which, according to the formula for finding the resistance of the shunt coils, $r_1^2/r_a = r_s$. The "back E. M. F." must be treated as a resistance in the following manner:—The E. M. F. of the machine is 88 volts, and when running at a rate of 1,300 revolutions per minute, it is *known* to give a current of 16 ampères through 27 cells; then, by Ohm's law, $88/16 = 5.5$, which is equivalent to 5.5 ohms total resistance. Then $5.5^2/0.8 = 34$ ohms, the required resistance of the shunt coils. Properly calculating this, the resistance of the armature ought to be deducted from the total resistance; but as in this case there are frequently reasons why the resistance of the shunt should be slightly more or less than the exact calculation, according to circumstances, such deviations from rule will be made apparent when the winding of field magnets is treated in these papers.

We must now proceed with the practical work of winding the taped armature, having endeavored to render the somewhat difficult question of the size and length of wire as clearly as possible. A piece of plank should be screwed to the ordinary work bench in such a manner that two persons may stand, one on each side, to work, the armature being clamped down to the board by a wood clamp passed through the interior. The operator and his assistant thus face each other across the breadth of the armature core, as it were. The more skilful of the two, whom we shall afterwards describe as the "winder," stands in such a way that when winding he works from his side as the coils progress, from right to left, and the ends that are to be left for the commutator connections also terminate upon his side.

Now, two guides should be prepared of hard wood, having a stud and thumb nut for tightening upon the armature. These should *not* be thicker than the width of one coil, which is ascertained by reference to figure. The shape of the guides is shown in figure 8.

The first thing to be done now is to place one of the guides across the core, against one of the joints (ferrule and stud) on the winder's *right* side of the joint. A piece of wood of the exact width of the gap that will be left should be bradded to the guide in position, so that it will accurately fill the gap, of course temporarily, and the winding will commence from the winder's *left* of this. The other guide should be put in position, also to the winder's *left*, and a space left between the packing piece upon guide No. 1 and guide No. 2 equal to the width of one coil.

Two shuttles of hard wood, nicely rounded, a mallet, and a hard-wood wedge, with rounded and smooth edges and surface, now complete the winder's outfit.

Upon one shuttle should be wound, with a little to spare, the length of double cotton covered wire that has previously been calculated for one coil; then, if the winding is to be four layers deep, four full perimeters of wire should be wound off upon the second shuttle. In describing this operation, in order to render the use of the two shuttles more clear to the amateur, the first, holding the bulk of the wire, will be termed No. 1, and the other with four layers upon it No. 2.

Beginning close to the packed guide to his *right*, the winder passes No. 2 through the armature to his assistant, who thereupon hangs a weight to it, and then he receives No. 1 from the winder, *over* the top of the armature, passes it back to him *through* the interior, receives it again, and so on, straining tight each time, and bringing the strands level with the mallet and wooden wedge. A short piece of tape is laid upon each edge of the core, so that the last two turns pass over it, leaving an end of tape free when the other guide is reached. The last turn being laid close to the guide, the tape end is brought up between the wire and guide, then the first turn of the second layers is made by the assistant *over* the top with No. 1 shuttle, No. 2 remaining neutral all this time. The second turn of this layer should bind the tape end over the first, thus securing it from slipping when the guide is removed. Then a weight should be attached to No. 1 by the winder, while he gives the layer a good coat of shellac varnish. The tape ends should again be laid ready to bind in the last turn, and the winding proceed until one turn is required to bring the second layer close to the starting guide. Instead of performing this turn with No. 1, the winder hangs a weight to it when he receives it from his assistant at the finish of the last turn but one, and this final turn completed with No. 2 shuttle, which the winder passes back, and again re-

* It may be argued, and rightly, that the efficiency of such a machine is very low; but to obtain really good and efficient dynamos, the construction must be altered to such an extent as to place the manufacture beyond the capabilities of an amateur, especially if it is his first machine. The advantages of projections of mass in the armature core, few layers of wire, and other improvements are well known; but the writer is of opinion that the simple machines herein described, the manner of winding, and other details may stimulate to exertions on a larger scale, and in a wider field. In future papers the subject may be dealt with in a more advanced and scientific manner, and various forms and types of dynamos treated upon in detail.

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ceives from the assistant over the top, and returns *through* the armature, so that No. 2 makes the last turn of second layer and first turn of third, then is weighted by the assistant, and again remains neutral for a time.

The third layer now proceeds with No. 1 to the other guide, the last turn being taped as before, and the first turn of the fourth and last layer is begun with No. 1 shuttle, and wound until the last turn but one, when the assistant passes it *through* to the winder, when it should be nearly empty. No. 1 shuttle is then passed *over*, and completes the last turn, and with the end of wire from No. 1 and the end from No. 2 respectively, coming *through* and *over*, the winder pulls taut, and makes a neat and tight twist with the pliers, taking care to place some tape between the wires in case of a short circuit.

By this arrangement of two shuttles the final ends are brought out in the *last* layer, *over* and *under*, and the distortion and risk of short circuit consequent upon leaving the first end to protrude through the whole winding prevented.

The guides may now be removed, one only being required in the future, as the rigid wall of the first coil will form a sufficient guide for the second, and so on.

Each layer should be well coated with shellac varnish, and in the course of winding over the core, if at any part the tape insulation should seem insecure or abraded, a fresh piece may be stuck on with Prout's glue.

The whole armature is thus wound, each coil being a repetition of the first in every detail, care being taken that the *exact* length of wire be used on each, or there will be a considerable spark at the commutator when the dynamo is running.

The winder should also be especially careful to get the layers perfectly even and flat on the outer surface and ends of the armature. The interior necessarily differs, because the winding space is less, and the layers irregular in consequence; but this is out of sight, and, electrically and mechanically considered, is of little importance. The wheel ends may be temporarily put on, carefully bringing the ends of the coils through the arms.

Then put the spindle in, and key up, but not permanently, ready for running in the lathe. If the winding has been finished well, and the wheel ends are a good fit, the whole armature ought to be true, and any slight irregularity may be tapped down with a wooden mallet, and the six gaps filled up with wood. Presuming that it is true, however, the next thing to be done is to "bind" the armature, so that the centrifugal force set up by its rapid rotation within the poles may not cause it to fly apart and be destroyed.

A strip of tape 1½ inches wide is tightly bound round the centre of the circumference of the armature, and over this a strip of asbestos paper of equal width. Then a spool of No. 20 B. W. G. wire is placed upon a spindle behind the lathe, so that the wire will reel off freely. Ordinary copper wire is of no use for this purpose. The best material is phosphor bronze or Delta metal, both of which possess great tensile strength in proportion to the gauge.

Having put a carrier or driver upon the armature spindle, and put the back gear into action, the winder should take up his position behind the lathe, while his assistant prepares a soldering iron, resin, and solder. The winder then attaches the end of the wire to one of the projecting armature studs, and, beginning ⅛th of an inch away from the edge of the tape and asbestos band, he takes one turn of the slack wire round his mallet handle, and his assistant starts the lathe with a slow speed. Holding a piece of emery cloth in his hand, the assistant guides the wire in regular, even turns, cleaning its surface at the same time, the winder meanwhile keeping the wire very tight by means of his hold upon the mallet handle, and his foot being braced against the lathe bed.

Directly the winding has reached to within ⅛th of the edge of the tape band, the lathe must be stopped, and the assistant must "sweat" the band together with solder, and so secure the end, the winder keeping the wire tight meanwhile. The free ends having been cut off close, the whole band must be "sweated" all round, using a *hot* soldering iron, and plenty of powdered resin. The asbestos paper will prevent the tape or coils from being scorched.

The armature may now be removed from the spindle, and the wheel ends taken off, and preparations made for coupling the coils in "series." To do this the armature is laid upon the bench, with the wire ends uppermost, and then, beginning at any convenient coil, untwist the ends, strip and clean them down to within ¼ inch of the coils. Repeat this operation with the next coil, then cut the four ends off exactly two inches long, and take the *end* of the first coil and the *beginning* of the next, and twist these ends together (one twist only), bringing the rest of the two inch length out straight, even, and close together, and then "sweat" them along their length with solder. Repeating this all round, the *end* of the last coil will join with the commencing end of the first, and the whole of the coils will be in "series," and 48 ends two inches long, will be ready for coupling to the commutator, each end being a double wire, sweated together. A couple of yards of gutta-percha tube should be obtained from any chemist, of the kind used for nursery bottles, and this may be cut up into 48 lengths of one inch each. One of these pieces of tube should be threaded upon each connecting end of the coils, and pushed well down to the twist; also the whole of the twists should be well taped, by interlacing the tape between each connection, over and around the end of the tube. As far as wiring and winding are concerned, the armature is now ready for the commutator, and after receiving a good coat of shellac varnish, should be placed to bake at a gentle heat for a day or two if possible.

When the varnish is perfectly dry, the 48 ends may be tested for continuity, by coupling one to a battery and galvanometer, and touching each one all round with the other end of the wire from the instrument circuit. If all is right, the needle will deflect each time. Now, without removing the wire that is coupled to one connection, touch all the six studs with the other; there should be *no* deflection if there is not a "body contact" between the iron core and studs, or wire and studs. It should be remembered that perfect insulation should be carefully attended to, as a short circuit in the armature, or a "body contact" will sure to partially, if not wholly, destroy it, when the higher E. M. F. of the machine comes into operation. In practice this test is made by sparking, without a galvanometer, and with an E. M. F. of 100 volts.

(*To be continued.*)

SECONDARY BATTERIES FOR LIGHT AND POWER.[1]

BY A. H. BAUER.

So much has been written of the theory of secondary batteries, that I assume it would be more interesting to the members of this Institute to confine my remarks to a history of what has been done practically during the past three years with the Faure battery at Baltimore.

In May, 1882, a set of Faure batteries was brought from Paris by the steamer *Labrador*, and sent to Baltimore. This battery was composed of 60 cells, each containing ten plates, with a supposed capacity of 200 ampère hours at an E. M. F. of 2 volts. The plates were made of sheet lead, 9½″ long, 5½″ wide, and $\frac{1}{16}$″ thick, mechanically perforated with 400 holes $\frac{1}{8}$″ diameter. They were coated with a paste made by mixing sulphuric acid and red lead, which was held in place by wrapping the plate in felt. They were set in lead-lined boxes, with the terminals of five plates joined together with brass clamps to form the positive, and the remaining five likewise connected to form

1. Read before the American Institute of Electrical Engineers, New York, May 19th, 1886.

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the negative poles. Twenty-four of these cells were placed on exhibition in the offices of the Electric Storage Co., and arranged to run a lot of Edison B lamps, small motors, etc. The charging machine was an Edison Z A dynamo, located about half a mile from the office.

These batteries gave satisfactory service for about six months, when they failed rapidly—first one, and then another, would refuse to store, until nearly all had become useless. Examination disclosed many causes for the failure, which at that time was imperfectly understood. One of the defects was the interposition of felt between the plates, which increased the internal resistance; and after a time the felt got rotten and fell off, causing a short circuit.

Realizing these and other defects, the matter was taken in hand with the intention of evolving a practical battery with what results the following will show:

The first plate giving promise of success was cast in an iron mould; its dimensions were 12½″ long, 9½″ wide, and ⅜″ thick, weighing 6½ lbs. They were in the form of grids, having 480 holes ⅜″ square. These holes were filled even with the surface of the plate with 5½ lbs. of a mixture of red lead and sulphuric acid, and allowed to dry. Twelve of these plates (6 positive and 6 negative) were placed in a rectangular box lined with a mixture of pitch and asphalt. The plates were separated by pine boards 1/16″ thick. Forty of these cells were connected in series with an Edison 110-volt machine and charged with a current of 50 ampères for 300 hours.

From the first several difficulties presented themselves, one of which was that the wood boards prevented a free circulation of liquid between the plates, causing the charging current to pass from one plate to another at one or two points where the resistance was least. Another was the constantly increasing resistance due to the sulphating of the copper connecting strips joining plates and cells together. The next step was the removal of the wood boards and the substitution of pine strips ¼″ square section, and 10″ long; four of these were placed between each pair of plates; the copper connectors were painted with an insulating paint.

These changes made a vast improvement in the working of the battery. A number of cells that before had persistently refused to receive or hold a charge, now became active, and could be relied upon to give a satisfactory current. While with the same plates separated by boards, the internal resistance of the cells averaged 1/160 ohm, that of the same cells with ¼″ strips fell to 1/500 ohm. In the course of time, however, the copper connecting strips gave trouble. In spite of the insulating paint, the acid would attack the strips, forming sulphate, and developing a high resistance.

While much had been learned from these experiments, and some progress had been made towards a practical battery, yet it was seen that the great weight (250 lbs.) per cell of those in service must be reduced. About this time the writer visited London, for the purpose of studying the improvements made by the Electric Storage Company at Millwall. Immediately upon his return the subject was taken up anew. It was found necessary to make numerous changes. While the cast perforated plate was still used, its dimensions were reduced to 10″ long, 9½″ wide, and 3/16″ thick, and its weight to 2½ lbs. These plates were pasted with 2½ lbs. of active material. The only size cell made at that time was termed a A 1 h. p. cell.

$$\frac{E \times C}{746} = El.\ h.\ p.$$

and consisted of 16 plates (8 + and 8 —) in a lead-lined box, separated by pine strips ¼″ square section.

They had a capacity of 370 ampère hours at 2 volts E. M. F.,

$$\frac{2 \times 370}{746} = 1\ El.\ h.\ p.$$

Instead of using copper or brass rods, or strips for connecting the plates and cells together, lead was substituted. This battery showed a great improvement over the first made. It was found to be thoroughly reliable. It would retain its charge for months without practical loss. Numerous experiments were made to determine their capacity and efficiency. These tests have always been of a practical nature—two of which I will quote: 32 cells were charged with 20 ampères for 20 hours. A carefully calibrated ammeter was kept in circuit during the entire time.

To discharge, the battery was connected to two Weston arc lamps in series, and a current of 20 ampères for 16 hours was obtained before the E. M. F. fell to 1.5 volts per cell; this was equal to an efficiency of 80%.

The same test was repeated, except that Edison B lamps were used for the discharge with a return of 340 ampères or 94% before the E. M. F. had fallen to 1.5 per cell.

On May 1, 1884, an installation of 3 h. p. cells for supplying 255 16 c. p., 70-volt lamps was made at the Academy of Music, for lighting the stage. This battery is located in the cellar, each cell consists of 48 plates in lead-lined boxes and has a capacity of 1,200 ampère hours at an E. M. F. of two volts. The location is not the best for high efficiency —a well occasionally overflows, thoroughly wetting the framework on which the battery rests as also the wooden boxes themselves, causing at times, serious leakage and loss of current. Even under these adverse circumstances the battery is still in service and doing remunerative work.

The lamps used are the Weston 70 volt 8/10 ampère, and consist of 98 footlights of various colors, five borders of 20 lamps each, the balance being distributed among the dressing rooms, stage entrances, etc. Each border and the different colored footlights is on its own circuit and controlled by its own switch. An arrangement is used whereby the light can be raised or lowered from the stage by adding or subtracting any number of cells from one to 16 as desired, thus producing all the effects that heretofore had been done with gas. This battery is charged every night with two 10-light arc machines, giving a total of 50 ampères.

It is of course understood that during the time of a performance a current of about 230 ampères was required to maintain the lamps, of which the dynamos furnished 50 and the batteries the balance. As this demand was not continuous during a performance, the total time not being over four hours in 24, it is possible by running the two machines for an average of 10 hours per day to keep the battery thoroughly charged and always ready to furnish current when required. This plant has been in daily service for two years. At this writing another installation of 3 h. p. cells for supplying 300 38-volt Swan lamps is being made for the Crescent Club of Baltimore, and will probably be in service within the next month.

Some work has been done with the batteries for cautery, faradic and constant current purposes. For the cautery a current of from 10 to 30 ampères is required, depending upon the length of platinum wire to be heated, and as they are in service not more than one minute at any one time— small capacities are required. These batteries are made up with plates measuring 7″ long, 5″ wide and 3/16″ thick, weighing two pounds. For office practice they have a capacity of 200 ampère hours, and weigh 43 pounds; those made portable having a capacity of 25 ampère hours, and weigh ing eight pounds. They usually run from three to six months without recharging.

A very interesting experiment was made a short time ago with 50 secondary cells on the wires of the Western Union Telegraph Co. A wire from the battery was run to the Baltimore office to which were connected 38 Morse and three gold and stock circuits, the resistance of which varied from 50 to 6,000 ohms. At the same time three incandescent circuits consisting of 56 Maxim 25 c. p. and 24 Edison 8 c. p. lamps were also being supplied from the same battery. The number of cells of primary battery displaced

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was 1375 gravity and 110 carbon. The experiment was continued daily for more than one week.

Less than one year ago a battery consisting of 49 four-plate cells, having a capacity of 100 ampère hours, were taken to the Daft electric railway station near Baltimore, and placed on one of the motor cars used in that system and connected to the motor and switches in the usual way. An extra switch being used, however, to vary the E. M. F. by adding or subtracting a certain number of cells. The total weight of car, motor, batteries, etc., was about 5½ tons. Three trips of about one mile each was made. As this experiment was merely to show that the batteries could be used for the purpose no tests were made. Encouraged by the success of that experiment a 20-foot car weighing 5,400 pounds was borrowed from one of the Baltimore railway companies, and taken to the Viaduct Manufacturing Co.'s place where an eighth of a mile track was laid. The following described system was devised :

It consists of two beams extending between and resting on bearings on the two car axles. These beams carry a motor, counter shaft, and gearing. The armature shaft of the motor is extended and carries six inch pinions on each end which mesh into 20″ counter gears. On the counter shaft is a six inch pinion which meshes into a 24″ gear on the front axle of the car. The motor is wound in three sections, each section is connected to the battery by a double three point switch located on the platform by which one, two or three sections can be connected in circuit depending upon the amount of power the motor is required to develop.

In all previous experiments with batteries for power purposes the resistance of the motor was constant, the variation of power being had by adding or subtracting a certain number of cells. In the present system the number of cells in circuit is constant, and the current is varied by varying the resistance of the motor. In the former case a number of cells were exhausted while a number were in good condition, and at the end of a certain time an irregular battery was the result. In the latter each and every cell does the same amount of work and all are discharged alike. Although the tests of the system are as yet incomplete the following data may convey some information.

The resistance of one section of the motor plus that of the armature is .57 ohm, of two sections in multiple arc .32 ohm, and of three sections .20 ohm. The counter E. M. F. is respectively 70, 90 and 100 volts at 800 revolutions of the armature. The battery gives an E. M. F. of 120 volts, the internal resistance is .06 ohm. The track is about one-eighth mile in length and commences at the foot of a 1 in 20 grade on a curve of 45 feet radius. The total weights of the different parts of the system is as follows :

Car	5,400 pounds.
Motor	923 "
60 cells battery	5,400 "
Gearing	900 "
Total	12,623 pounds.

This car has been running almost daily for the past two months, and with the exception of an accident due to the irregularity of the track causing a run off when coming down grade on the first trip, no trouble has occurred, and no changes or alterations has been found necessary. Sixty cells of battery of a total weight of but 2,580 pounds are now being tried. The large size gives a continuous run of 36 miles. It is expected that the smaller should be able to propel the car 18 miles.

As before stated the tests are very incomplete, and I regret I am not able to give you data sufficient to judge of the merits of the system.

There are many experiments that we were obliged to make in order to become thoroughly acquainted with the battery, and which it would only take up your valuable time to mention. I will, therefore, merely add a few words in regard to certain erroneous ideas that have been held by a large number of people respecting batteries in general and storage batteries in particular.

When the announcement was first made of the great discovery by Camille Faure, it was also said that the secondary battery was a simple contrivance composed of lead and sulphuric acid put together in certain proportions placed in wooden boxes, carted around the city and delivered to subscribers at stated times, that it could be placed in the cellar, vault, or some other out-of-the-way place, and without any attention whatever would always be ready to furnish current at any moment either day or night. Such ideas instilled into the minds of an unthinking public has done great injury to the battery interests. A little thought and study would have shown the fallacy of these promises.

A secondary battery requires precisely the same amount of care and attention as a dynamo or other source of electrical energy doing the same amount of work. As a matter of comparison suppose the plant at the Baltimore Academy of Music to be run from a dynamo capable of maintaining 255 16 c. p. lamps. In addition to the dynamo a 30 h. p. engine and boiler will be required. Now to properly take care of the installation it will be necessary that at least one man give it his entire time and attention. At stated times the boiler will be thoroughly examined. He will probably use a compound in the feed water or take other means to remove scale. He will watch his gauges very closely to see that the proper quantity of water is in the boiler. His engine will be set perfectly level on at least a six foot foundation, and all its moving parts closely watched to prevent an accident and stoppage. If he be attentive the engine will be kept scrupulously clean. His dynamo will receive as much if not more attention than any other member of the plant. He will use a good quality of oil in its cups and see that it feeds properly to prevent undue friction in the bearings. He will be extremely careful to prevent dirt, dust, etc. accumulating on the machine, and whenever possible he will remove the armature, clean it of dust and dirt, and give it a coat of shellac. If he be attentive he will see the necessity of closely watching all parts of the plant. Compare all this care and attention absolutely required by a direct lighting plant to that heretofore supposed to be required by a secondary battery doing exactly the same amount of work.

How is it possible to place a battery in a damp cellar, and with little or no attention expect it to do satisfactory work at the rate of 25 h. p? Batteries as now constructed have an E. M. F. of 2 volts and an internal resistance varying with the number of plates per cell. Given a battery of 100 cells (3 h. p.) we have a total E. M. F. of 200 volts and an internal resistance of $\frac{1}{10}$ ohm, with this comparatively high potential and low resistance what is to prevent a constant loss of current by creeping, if such a battery is located in a cellar, and covered with dirt and moisture? I have seen batteries working under such unsatisfactory conditions. On account of its great weight and the fact of sulphuric acid being used, it is best that the battery should be placed in a cellar—but the cellar should be dry and clean and well ventilated.

The first and most important point to be observed is to carefully insulate the cells from each other and from the earth. The plan I have adopted is to use 4x4 scantling well painted with asphalt varnish—the scantling is insulated from the earth, by the ordinary pin and glass, the glass being inverted and kept filled with paraffin oil. On the scantling are placed large porcelain insulators, four for each cell—on which the cells are set—the cells are kept one inch apart so as to allow a free circulation of air around the boxes which keeps them dry. As the tops of all the boxes are on the same level and about three feet from the floor, they can be easily examined. A reliable voltmeter and hydrometer should be provided so that each cell can be tested every day or two, to discover if any one is becoming faulty. Sometimes a square of active material will drop out, and lodge on the positive and negative

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plates making a circuit of comparatively high resistance between the two, which will in time completely discharge the cell. A test with a voltmeter will indicate a fall of potential, and the hydrometer will show a fall in the strength of the acid solution in a cell so troubled and the cause may be removed in a few moments. A fault of this kind will probably be understood when it is explained that the plates of a secondary battery contract when being charged, and expand while being discharged.

If the correct strength of solution has been used when the battery is first set up, a good hydrometer will also indicate the amount of current that has been taken out, which should not exceed 85% of the capacity.

Right here I would remark that within certain limits it is impossible to overcharge a battery—but it can be completely destroyed in a very short time by over-discharging. During discharge sulphate of lead is formed, and that is the destroying agent in secondary batteries.

In conclusion, I wish to emphasize the assertion that secondary batteries have passed beyond the experimental stage. They must, however, be properly constructed; they must also have a capacity proportionate to the work they are intended to do. Such a battery can be placed in the hands of any one of ordinary intelligence, who, if he follows instructions and will give it the same amount of attention required by mechanism doing the same quantity of work, will meet with little or no trouble; on the contrary, the battery will be found always ready to furnish current at its maximum potential.

THE GREAT TANGENT GALVANOMETER OF THE CORNELL UNIVERSITY.[1]

BY PROFESSOR WM. A. ANTHONY.

The "mammoth tangent galvanometer" which was described in the Electrician and Electrical Engineer, of October, 1885, has now been in use for nearly a year, and it may be of interest to the Institute to hear a brief account of its working. It will be remembered that the instrument was constructed primarily for the direct measurement of large currents, and its large dimensions were necessary to adapt it to that purpose. At the same time it is possible to measure by means of it, currents as small as 1-100th ampère. The instrument is fully described in the Electrician and Electrical Engineer, but a brief description is given here in order that the various uses to which it has been put may be better understood. The needle is made of a number of thin wires, is hung in a copper block, and is very nearly dead-beat. The apparatus for observing deflections, gives these accurately to 20 seconds. The coils for heavy currents each consist of a single turn of copper rod 1.9 cm. diameter. There are four coils, two of them 200 cm. and two 160 cm. diameter. These are placed parallel to each other, the two coils of a pair being at a distance apart equal to their radii. As the coils can be used in series, in pairs, singly, or differentially, it will be seen that the galvanometer may be equally sensitive to widely different currents. In fact, currents of any value from 4 to 250 ampères, can be measured by deflections of the needle never less than 25 nor more than 60 degrees. Four coils of 18 turns each of small wire, serve to measure smaller currents. The instrument has been used for measuring currents of dynamos under test, for measuring currents for standardizing other instruments, and for a great variety of experimental work.

Its indications have been compared with those of the copper voltameter, with generally a very close agreement. The disagreements that have been observed, have been traced to irregularity in the action of the voltameter. It has also been compared with a calorimeter with very satisfactory results. All the observations that have been made with it, go to show that its indications may be implicitly relied on. In fact, those who have used it, have come to feel the same confidence in the results obtained, as when weighing a body on a good balance. In the use of the instrument, readings can be taken very rapidly, ten minutes sufficing for twenty readings which are ordinarily taken as a set in measuring currents, and the computation of results is extremely simple. There are no temperature corrections except where the highest degree of refinement is aimed at. The only correction that need to be considered in any ordinary case, is that due to variations in the horizontal intensity of the earth's magnetism, and the instrument contains within itself the means of determining the horizontal intensity at any time.

The advantages of the galvanometer over other methods of measuring large currents, will appear by considering the sources of error or uncertainty involved. Currents may be measured by shunting a smaller tangent galvanometer. Here the errors depending on the instrument itself are the same as for the larger instrument, but larger in proportion, since the dimensions of the smaller instrument cannot be measured with the same percentage of accuracy as of the larger. But in addition to these, there is the uncertainty in regard to the shunt ratio, which depends upon temperatures very difficult to determine accurately. With copper conductors, a change in the ratio of one per cent. would result from a difference of temperature of a very few degrees.

Theoretically, the best way to measure currents would be by reference to their own mutual action. That is, by means of some form of the electro-dynamometer. But any such instrument, when constructed for measuring large currents, involves large sources of error. The instrument must be of large dimensions, otherwise the cross section of the conductors will be large in proportion to the distances between them, a condition which makes it impossible to determine the constant of the instrument with certainty. The forces to be measured are very small, and any arrangement for carrying the current to and from the movable coil, must seriously interfere with its freedom of motion and so impair the sensitiveness of the instrument. The writer of this paper had planned to construct a dynamometer in which a movable coil should be suspended from the arm of a balance, and the force exerted between it and the fixed coil, *weighed*, but no method could be devised for reaching the suspended coil with a current of 20 ampères even, without a loss of sensitiveness that was fatal.

Currents may be measured by determining the deposit of copper or silver. In theory this is very simple, but in practice, constant results can be obtained only by observing many precautions, and even with the greatest care, results will sometimes differ by one or two per cent. from the truth, without apparent cause. Moreover, these voltameter methods are not generally available, as they require too much time, and give only a time integral of the current, and not its value at any given instant. They are only of value for the calibration of instruments whose constants cannot be determined from their own dimensions, such as the various forms of ammeters, including the so-called "Vienna method." The indications of all such instruments are uncertain, unless they are frequently calibrated. If permanent magnets are used to produce a magnetic field, they are liable to a continuous change, and they always change in strength with change of temperature. If any of the forms of mirror galvanometer are used, as in the "Vienna method," the slightest change in the position of the needle with reference to the small coil, such as might occur from a stretching of the fibre, will change the constant.

To sum up: The tangent galvanometer is a very sensitive instrument, and its constant depends only upon its dimensions and the horizontal intensity of the earth's magnetism. Temperature affects the constant only as it affects the dimensions of the instrument. For the shunted galvanometer the constant depends upon the same elements, with the addition of a very uncertain shunt ratio.

1. Read before the American Institute of Electrical Engineers, May 19, 1886.

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The voltameter is usually inadmissable for direct measurements of currents, and the method requires extreme care to avoid errors in determining the deposit, which errors may arise from some of the solution being occluded in the deposited metal, or from loss of the metal while washing, or from other causes, difficult sometimes to assign. Moreover, this method is not an *absolute* method. Electrodynamometers, when constructed for use with large currents, lack sensitiveness.

Of course, the large tangent galvanometer is not a portable instrument. Few instruments of precision for absolute measurements are. It must be mounted in a place free from local magnetic disturbances. But it is the conviction of the writer, after extended experience, that, for purposes of accurate testing, or for standardizing other instruments, there is no other method for measuring currents, so reliable, so accurate, and so expeditious.

PHYSICAL LABORATORY OF THE CORNELL UNIVERSITY, May 15th, 1886.

SOME RECENT ADVANCES IN TELEPHONY.[1]

BY THOMAS D. LOCKWOOD.

TEN years ago a meeting of the American Academy of Arts and Sciences was held in Boston, at which Alexander Graham Bell expounded his ideas upon the electric speaking telephone.

Prior to that date a patent had been issued to the same gentleman upon the same subject; a patent which many persons state they have since ascertained refers in no way whatever to the speaking telephone; a statement which many other persons, perhaps equally well informed, believe to be based upon a wish that such were the case.

The first line built between two distant points expressly for telephonic transmission, was completed April 4, 1877, and extended from the office of the electrical manufacturer, Mr. Chas. Williams, Jr., 109 Court street, Boston, to his house in Somerville, a distance of about three miles.

May 1st, 1877, the first lease of telephones for private line service was effected; and in May, 1877, telephones were first operated upon the exchange plan through a switch board in the office of Mr. E. T. Holmes, 342 Washington street, Boston; the sub-stations comprising a number of different offices connected with the Holmes burglar alarm system by wires converging to Mr. Holmes's office. For a number of years it was assumed that the exclusive field of usefulness for the telephone like that of the average and proverbial specimen of charity, not only begun, but also ended at home; that the local short line, or exchange service, was the only kind in which telephones could, or would be, practically used. Recent experience proves this assumption as hardly correct. The exchange, or central office service, it is true is the more immediately practical and obvious utilization, and it was natural that the American people should measurably fill that sphere of action before looking for others, inasmuch as that was the line of operation promising the most speedy pecuniary return for the outlay. Lines of from a few yards, to a dozen miles in length have, however, been connected with exchanges, and these have in turn been supplemented as occasion served, by what are technically termed extra territorial lines; that is lines connecting different exchange centres; and from 1879 to the present time it has been a regular practice to talk over such lines with comparative ease perhaps for an average distance of 40 or 50 miles. In some of the western states it has been a common thing to converse by telephone over much greater distances by switching lines together, but not always with ease.

I think it well understood now that three conditions have conspired to retard what is at present termed long-distance telephony. These are:

(*a*) The uncertainty of obtaining satisfactory and speedy reciprocal communication, and the consequent slowness of transmission together with the inevitable result of such uncertainty, namely, the low prospective maximum capacity of remunerative transmission.

(*b*) The extreme noisiness of long lines, and increased telephonic induction, or cross talk, which in many cases renders the single or earth terminal circuit insufficient.

(*c*) The lack of transmitting instruments sufficiently powerful and trustworthy to develop voice currents capable of overriding the undesired currents and the noises produced thereby, and of sufficient E. M. F. and volume to affect the distant receiver with clearness and strength.

If it be asked at the present time "what is long-line telephony?" I answer—"Telephonic communication over lines more than 50, and less than 500 miles long." Six years ago I should have limited it to lines between 20 and 50 miles long, and six years hereafter I may possibly fix the limits of long-line telephony between 250 and 1,500 miles. The term is purely comparative.

The most noteworthy advance of the telephone in the past few years has been in the direction of increasing the distance over which communication can be transmitted satisfactorily, and the advance which has been made is, I think, undoubtedly attributable to the introduction of copper line wire, and to the radical improvement of the transmitting telephone.

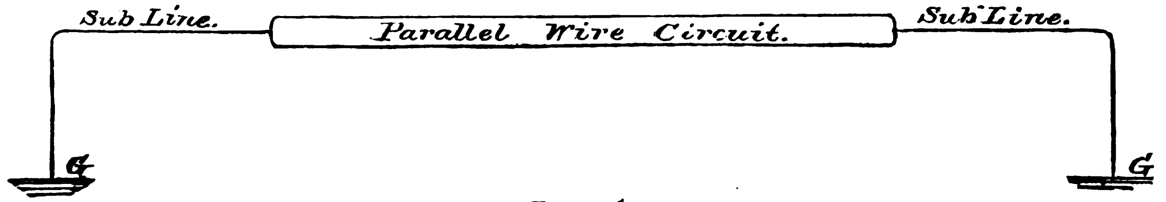

FIGURE 1.

It must not be supposed that telephone communication over long lines was until recently entirely unknown, even when we accept the above definition of a long line.

On the contrary it is a well authenticated fact that in the earliest days of the speaking telephone, time and space were well nigh obliterated.

In the remote period when the magneto speaking-telephone was the only known—and was itself a new and wonderful thing—it was operated over lines of (for that time) really considerable length. On August 11th, 1876, for example, conversation was carried on at Brantford, Canada, over five miles off, between Brantford and Mount Pleasant, and on the succeeding day the length of line was increased to ten miles.

As early as November 10th, 1876, a very long line was successfully used. I find among the early records of telephony the following statement: "November 10, 1876. "We carried on a long conversation on the lines of the "Eastern railroad using part of the time a circuit from "Boston to Salem (15 miles) and part of the time a circuit "from Boston to North Conway and back to Salem, and "from Boston to Portland and back, about 200 miles of "actual wire."

This statement is made by Mr. Watson (who like De Sauty was long supposed to be a suppositious character, being always at the other end of the line) and is noticed in the Boston *Post*, *Globe*, *Advertiser* and *Herald* of November 27, 1876.

1. Read before the American Institute of Electrical Engineers, May 19, 1886.

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In the early spring of 1877, with a box and magneto telephone, Mr. Bell in New York, conversed with his associate in Boston on a Sunday, and he speaks of the occasion in the following words:

"The longest length of real telephone line through "which I have attempted to converse has been about 250 "miles."

"On this occasion no difficulty was experienced so long "as parallel lines were not in operation. Sunday was "chosen as the day on which it was probable other circuits "would be at rest. Conversation was carried on between "myself in New York, and Mr. Thos. A. Watson in Bos- "ton, until the opening of business upon the other wires. "When this happened the vocal sounds were very much "diminished but still audible."

"It seemed indeed like talking in a storm. Conversation "though possible could be carried on with difficulty."

There are in fact a number of such isolated cases and I have thought proper to refer to these as showing that the idea at least is old, and that the magneto telephone is not an utterly incapable instrument, even viewed as a transmitter. There is, however, a wide gulf between an occasional successful experiment, made under favorable conditions in which experts can understand one another, and regular every day successful commercial communication.

If by recent developments this gulf has not been permanently and solidly bridged, there has at least been a convenient and useful ferry established.

Before leaving the early years of the telephone, it may amuse, if it does not instruct, to refer to an item which appeared in the *Scientific American* on November 29, 1879, entitled "How far can we hear with the Telephone?"

"This is a question frequently asked, but one which we "believe has not yet been definitely settled. The longest "distance that we have seen mentioned, is given in the "item below, namely two thousand miles. But perhaps "Mr. Edison has had more extended experiences. If so, "we should be glad if he would let our readers know. An "exchange states that Mr. Robert A. Packer, superintend- "ent of the Pennsylvania railroad, is at present hunting "with a party of gentlemen in Nebraska. A few days ago "he for two hours conversed pleasantly with his wife and "friends at Sayre, Pa., his brother at Mauch Chunk, Pa., "and his friends along the line. The medium was the rail- "road and Western Union Telegraph wires, and Edison's "telephone. At the office in Bethlehem, Pa., connection "was made with the Easton and Amboy wire, and at "Perth Amboy with a Western Union wire and thence to "Chicago and North Bend, Nebraska, where the party are. "The distance was about two thousand miles and every "whisper was audible."

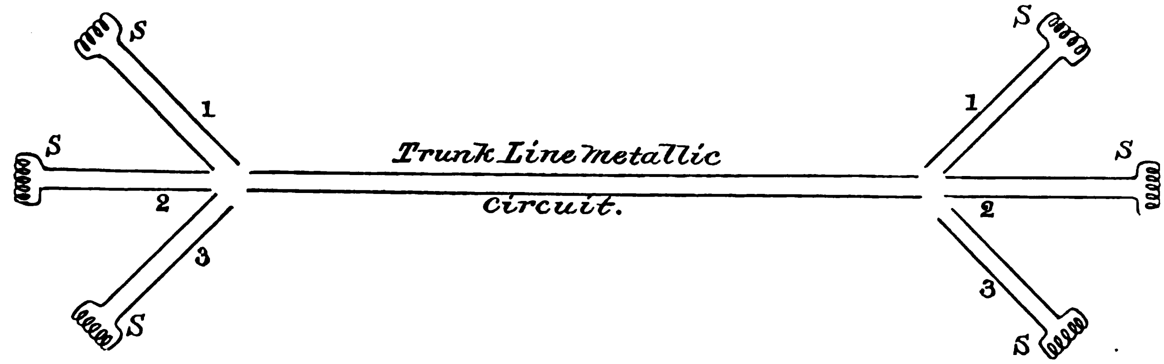

FIGURE 2.

Now if there is anything in the world that annoys one, it is to hear an apparently trustworthy account of something being done in one's own special line of work which, with every appliance for the purpose, with experience and special education, we cannot do ourselves. It is not therefore speaking too strongly when I say that this statement both mystified and exasperated me, for I knew certainly that at that time I could not accomplish such a feat; but I possessed my soul in such patience as I could make available and awaited developments; having at least a suspicion that there might be an error in fact, seeing that the veracious chronicler had already committed himself to the statement that Mr. Packer's business relations were with the Pennsylvania railroad instead of the New York and Pennsylvania Canal & R. R. Co., as it should have been. I had not long to wait however. In the issue of December 27, 1879, a second item appeared entitled "Long-Range Telephoning" (I think the original one should have been called "Long-Range Reporting") which read as follows—

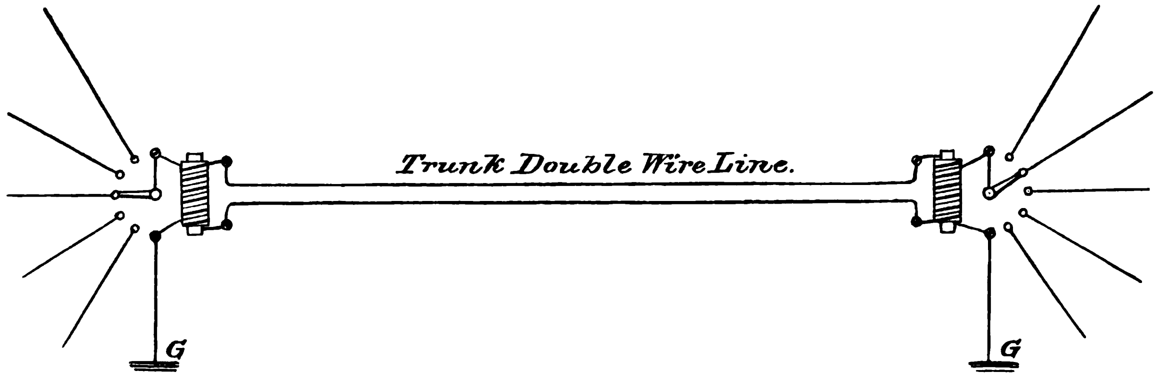

FIGURE 3.

"In a recent issue of this paper an exchange was credit- "ed with the statement that Mr. Robert Packer while "traveling in Nebraska, had conversed with his wife and "friends at his home in Sayre, Pa., two thousand miles dis- "tant, by means of a telephone. We now learn on good "authority, that though Mr. Packer's friends received his "communication by telephone it was not so sent by Mr. "Packer. The message was sent from Nebraska to Mauch "Chunk, Pa., by telegraph; thence it was telegraphed to "the Sayre office of the Pennsylvania Canal Railroad Co.,

"(of which Mr. Packer is superintendent) and from there "it was transmitted to Mr. Packer's house by telephone, "falling short of the newspaper report of the telephone's "performance by some nineteen hundred and ninety-nine "miles and a fraction."

Such is a sample of the long-range telephony of 1879.

When in the summer of 1879 a telephone line of two wires was built between Boston and Lowell it was regarded as a great achievement; for it worked well. It however opened our eyes to the phenomenon of induction in another phase to that in which it had heretofore been made manifest.

That phase in fact which in more recent times has been named "cross-talk." We found that when conversation was transmitted upon either wire, it would be heard equally well upon the other at the receiving station, and until many other lines were built, it was found practically impossible to operate both lines at once.

This was the beginning of lines to connect distant telephone exchanges and the seed from which sprouted the long-line telephony of to-day. When, however, the value of copper as a material for line wire was recognized, the commercial feasibility of long-line telephony, as above defined, became a subject of serious consideration, and exchanges located 75, 100 and 150 miles apart, were brought into conversational proximity.

The possibilities of the telephone were never brought before my mind in so striking a manner as when I stood in a little room on Broadway in this city, and talked with a fellow mortal in Cleveland, Ohio. Many of the members of this institute will doubtless remember that when the compound wire of the Postal Telegraph Co., was built and communication over it completed in 1883, first to Cleveland, and later to Chicago, a noble army of telephonic patentees hastened to try their patented telephonic receivers and transmitters over it, and how each and all, after successfully exchanging words with the western cities, went forth proclaiming to the world the unparalleled excellence of their special form of telephone.

When I first heard these statements I was firmly convinced that the achievements described, were due not to any special excellence of the instruments employed, but to the greatly superior conductivity and insulation of the Postal wire over any other that had heretofore existed, and my conviction was intensified after I had had an opportunity to make the test myself and had found that, not only could we make a Blake transmitter transmit speech which was perfectly reproduced at the receiving station, but that identical results could likewise be achieved with the magneto Bell telephone commonly used as a receiver.

To Mr. Thomas B. Doolittle, of Bridgeport, is due the credit of having first discerned the merits of copper as a material for telephone lines. A line of hard-drawn copper was erected by that gentleman in November 1877, in Ansonia, Connecticut, a section of which was taken down in August 1884, and found to be, when compared with any iron wire of like age, in an excellent condition. I may also say that from the first moment of my acquaintance with Mr. Doolittle, I have found him a strong and persevering advocate of copper wire for telephone lines, and, considering our present views upon the relative merits of iron and copper, it is fair to say that I think he has made out his case and was considerably ahead of the times. My own fear was that it would prove too soft for common use, would not stand up, would expand under increase of temperature and would fail to duly contract upon the resumption of normal temperatures. I had no doubts of its electrical merits.

The postal wire, however, was electrically so far ahead of all expectation, telephonically considered, that it seemed to prove once for all that copper, if mechanically available, was decidedly the proper material to use and it seemed also evident that if it would stand up alone it would be even more successful as a conductor, if the steel core were dispensed with.

Hard-drawn copper wire was tried after being submitted to the various electrical and mechanical tests, and was not found wanting. In fact it promised well, and the result was the erection of an experimental line of two wires between New York and Boston which worked satisfactorily, and with sufficient reliability to encourage its proprietors to build a line of a number of copper wires between New York and Philadelphia.

The experience gained in building, testing, and operating the Boston line has been utilized in the more recent one, which is a model line in many respects.

When we begun to use copper for this purpose, it was not easy to account for the comparative ease with which a line built of that material could be operated. It was attributed by many solely to the low specific resistance of copper, and I recollect instances where I have commented upon this remarkable point and have been met with the remark "Oh, it is only a question of resistance." But it was obvious that there was some more deep seated reason, than the low specific resistance; for, if we take two lines of equal resistance, one built of copper and the other of iron, the copper is invariably by far the easiest one to work.

This was, I confess, for a long time a problem to me, but has recently been wonderfully cleared up, by the masterly researches of Professor David E. Hughes, as detailed in his inaugural address, lately delivered before the Society of Telegraph Engineers and Electricians; with which every electrician interested in the communication of intelligence should familiarize himself.

His experiments showed that the E. M. F. of the extra current, in a solid iron wire is much greater than in a similar copper wire; that ordinary iron wire has, with rapid currents, more than three times the resistance during actual work than that supposed to be its resistance (although with stranded iron and ordinary copper such is not the case), and that the extra current in wires furnished with a parallel return wire is much reduced, but much more in copper than in iron. Iron 15 per cent. and in copper 80 per cent.

It is also interesting to learn that the E. M. F. of the extra current in brass wire, compared with copper, is but as 13 to 20. This point may prove useful when a wire, stronger than copper, but of equal size, is at any time required.

These researches are so interesting and valuable that they gratify me nearly as much as though I myself had made them. I am aware that the statements of Prof. Hughes have been severely criticised by Prof. Weber and others, as was to be expected, but I am persuaded that his results will, in the main, be ultimately approved, and his views acquiesced in by the world of science; although it is very probable that some errors of detail may be found in them.

Approaching now advances made in instruments, I may say that it is noteworthy that nearly every improvement has been made in the transmitter. There are two good reasons for this. The first being that the receiving telephone came into existence well nigh as sensitive and perfect an instrument as it was possible to make it; and the second that in view of the noises, made apparent in the receiver on long lines, due to undesired currents, it was manifest that the transmitting power it was that required intensifying, to the end that it might be able to develop currents of sufficient strength to override the disturbing currents, and that if a transmitter of sufficient power could be made, it was even possible to reduce the sensitiveness of the receiver, and thus weaken the disturbing noises by thickening the diaphragm, or by removing it to a greater distance from the magnet. The form of transmitter which has been found most successful is one in which granulated carbon in a loose and free state is employed as the current regulator. When first introduced it

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consisted simply of a handle, having a disc-shaped cavity cut in its face, the bottom of the cavity being faced with some suitable metal or alloy as copper, silver or brass.

The front of the chamber was closed by a piece of platinum foil, which served as a vibrating diaphragm, and the sides of the chamber were formed of the same non-conducting material as the body of the handle itself. The space between the back and front plates was partly filled with the carbon granulations, and the front plate protected by a mouth-piece. The instrument was then complete, and, though exceedingly simple in construction, worked, and worked well. When in use, it was most efficient when held so that the diaphragm presented an angle of about 45

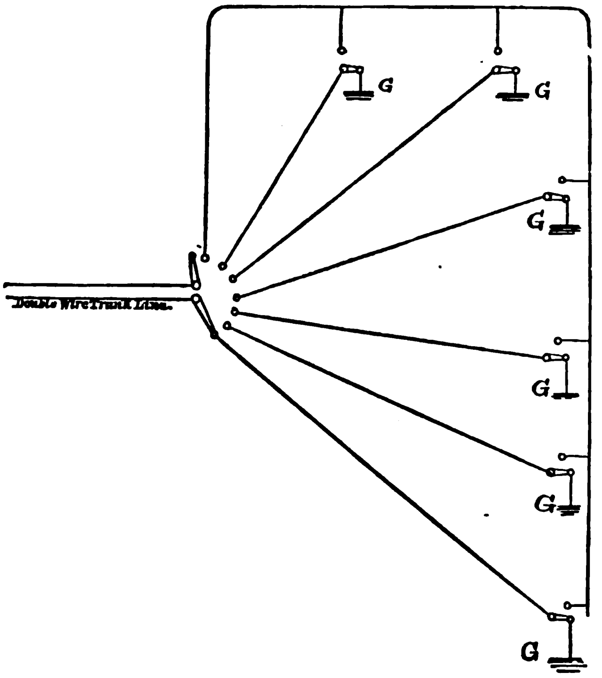

FIGURE 4.

degrees from the vertical position, the upper edge being inclined backwards.

When this instrument was good, it was "very, very good," and like the little girl of the nursery rhyme, when it was bad, it was "horrid."

It had one grave fault, the granulating powder would occasionally pack itself into a mass, and was then anything but as sensitive as it should be; under such circumstances it became a very poor transmitter. The customary remedy for this disease may be indicated by the familiar words of counsel, invariably found upon the apothecaries label, "When taken, to be well shaken," and, when shaken, the sick transmitter would usually resume its duties. But an ounce of prophylactic is better than a pound of medicine, and the want was decidedly a transmitter equal to the Hunnings, but which would not pack.

The first step was the adoption of a horizontally mounted diaphragm, the speaking tube of which ended opposite to the lower face, and it was found that when the carbon granules were placed on the upper surface of this plate, the voice vibrations acted upon them with great force, and tended to loosen them if packing had begun. This was not, however, completely satisfactory. It was subsequently ascertained that the back plate should, to obtain the best results, be buried in the mass of carbon which lay on the diaphragm, or should dip into the same in the form of a pendant, and that the resistance of the entire instrument should be reduced as much as possible.

One form, invented by Mr. Blake, employs for the complementary, or back electrode, a metal sieve, which is buried in the mass of granular carbon. In another form the back electrode takes a form something like that of a shade roller pulley, and has a number of holes bored through it in different directions, so that the carbon granulations can freely circulate. In both cases it is found advantageous to plate the electrode with some unoxidizable metal—such as gold; and to form the diaphragm as in the original Hunnings instrument of platinum foil.

One of the circuit wires is united to the diaphragm, the other to the back electrode, and the mass of granulated carbon lies upon the former with the whole or a portion of the latter immersed, or buried in it. These transmitters give admirable results. The tone, volume of sound, and clearness of articulation developed by them is most encouraging, and by their use the range of long-distance telephony has already greatly expanded even on long, single iron wires. The distance that they can be efficiently operated has not even yet been authoritatively ascertained, but, judging from the fact that instruments of the most inferior character can be made to maintain successful conversation between New York and Chicago over a compound wire, we are encouraged to believe that conversation can be easily transmitted over much greater distances than that by availing ourselves of the most improved forms of Hunnings's telephone. It is well known that long telephone lines are greatly troubled by the noises manifested in the receiver; these noises being due to magnetic or current induction, leakage from other wires, atmospheric and earth currents, and magneto-electric currents induced in them when they are blown about, and thus made to move across the magnetic lines of force of the earth.

It has been found necessary in order to reduce these disturbances to a minimum to adopt an old laboratory expedient, and to provide each line with a wire return as nearly as practicable equidistant with the direct wire from all known sources of disturbance, so that the disturbing currents, proceeding in the same direction on both sides of the circuit, will neutralize one another. But when we take such a double wire we find that it is not easy to preserve its benefits, and at the same time to connect it with a short exchange line at both ends, for, if we take a parallel wire metallic circuit trunk line and connect it with a short subscriber's single wire line by absolute contact, as in figure 1, it is obvious that we have lost the basis of neutralization, and only gained a conductor of lower resistance.

There are two plans from which we may choose. We may run a double wire to each subscriber wishing to use the long line facilities—as in figure 2—in which case the problem is at once solved; for, when we unite the two terminals of the subscriber's short loop line with the two wires of the long trunk line, we have simply extended the said trunk line half a mile or a mile, or whatever distance it may be, further.

This plan, however, presents some disadvantages, in that it necessitates a double wire for each subscriber's line, and the concomitant changes in apparatus at the central station; and it is, after all, rather an inordinate expense to incur, when the subscriber may possibly only use the long line once a month.

The alternative plan is to employ repeating translating coils. These are really induction coils of peculiar construction, the two circuits of which are made much nearer each other in the size of wire and resistance than is usual in the ordinary coil.

One of these circuits—that which is composed of the finest wire, and which is wound to the highest resistance—is connected in circuit with the two ends of the long metallic circuit trunk line, while the remaining coil has one terminal, united to the single central station end of the subscriber's line, and the other attached to a ground wire. This arrangement is shown in figure 3, in which one terminal of the local side of the coil is represented as being united with a button switch by which it may be connected with any desired subscriber's line. The beneficial results of the neutralization of the disturbing currents are thus obtained, these being at least minimized by means of the

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return wire; while the telephonic currents induce currents of like character in the coil which is in circuit with the shorter and local line, thereby reproducing the transmitted speech in the receiving telephones connected therewith.

The reason for making the two circuits of these translating coils so much more nearly equal in character and conductivity than are those of the ordinary induction coil, is that each is in turn the inducing and induced circuit—that is, the conversation is transmitted from the long trunk line to the short subscriber's line, as well as from the short line to the long metallic circuit. Each is, therefore, required to exercise the functions of both primary and secondary coil. I have every reason to believe that the first instance of the use of an induction coil in this capacity was by Mr. Thomas Watson and myself, in September, 1879, immediately after the completion of the two lines between Boston and Lowell.

We used the two lines between the cities as a trunk metallic circuit, and by means of two induction coils, one at each end, two exchange lines were inductively connected with the main line. I operated the ground circuit at Lowell, Mr. Watson engineered the induction coil at the Boston exchange, and Mr. Theo. N. Vail was at his own office in Boston, and talked with me through two induction coils.

The coils we then used were wound with both circuits approximately equal, about 250 ohms each, and were wound together from beginning to end, two wires being wound on the spool at the same time, a mode of construction which, by the way, experience has, I think, demonstrated to be the most satisfactory for inductoria intended for this purpose, and which will probably be adopted.

It is proper to note that we were led to this idea by considering the mode of using the transmitter induction coil which was even then well known; this use, however, though analogous is not identical, for it must be remembered that in the transmitter coil the iron core is maintained during action in a state of magnetic polarization by the battery currents, whereas the currents, traversing the surrounding circuits of the translating coil, have not sufficient strength to effect such a state in the core, and the induction in these coils is, therefore, almost entirely current induction of one of the coil wires upon the other, the magnetic reactions between coil and core being necessarily trifling in character. The induced effects may, however, be intensified by separately magnetizing the core either by a separate battery coil or by a permanent magnet, and I have sometimes done this with advantage.

A third plan whereby the double line may be conveniently connected with any one of a number of short grounded lines, without depriving it of any of its virtue, has been patented by Mr. Geo. H. Bliss.

This is indicated by the figure 4. It consists in extending from the central station an additional line wire, which may branch into as many sub-stations as are intended to use the long double wire trunk line. Each of these sub-stations may be fitted with a button switch which, when turned in one direction, will retain the telephones in their ordinary ground circuit, but which, when turned reversely, will disconnect the subscriber's line from its ordinary earth terminal and unite it with the branch from this extra circuit, thus providing a double, although not a parallel, wire between the central and sub-station, both ends of which may be then united with the two ends of the metallic circuit trunk line.

One extra wire of somewhat abnormal length is thus enabled to serve in place of a great number. It would be easy to fit the telephone call boxes with a double gravity switch and two separate telephone receivers, one on each side of the bell box, and to so connect these switches with the circuits that it might be invariably understood that when the receiving telephone on one side is taken from its place and used, the line would be used in its normal condition, but that the other telephone, when taken up, would connect itself and the transmitter in the loop circuit. One could then be always used for short line and the other for long line work. I am very favorably impressed with this, and do not believe that it has yet had the trial it deserves.

I am conscious that this paper already is too long. I may not, therefore, on this occasion describe at length the specialities in switching and signaling appliances which have been found necessary, and have consequently developed in the practice of long-line telephony, but hope either to say or listen to something of this branch at some future time.

I have, I think, said enough to prove that long-line telephony is a reality, the *New York Times* on contract obligations to the contrary notwithstanding.

THE INSTALLATION AND MANAGEMENT OF ARC LIGHTING PLANTS.

BY J. M. ORFORD,

Superintendent of the Bridgeport (Conn.) Electric Light Co.

(Continued from page 177.)

CHAPTER II.

LOCATION OF THE STATION.

In deciding upon the most desirable locality for the station a number of different considerations should be taken into account. Among these are the conveniences for the delivery of coal, the water supply, proximity to the greatest number of customers or as it may properly be termed, the centre of consumption, and the facilities for setting poles and running wires. If the coal is brought by water, of course, waterside premises with wharf accommodations are desirable. If brought by rail a location near the track would be preferable, and if possible a siding should be brought into the station. On the other hand if these conveniences can only be secured by locating the station at a distance from the majority of the customers, then the question arises which advantage had best be sacrificed. The difference in the price of coal, whether delivered directly from the car or boat, or at the station by dealers is usually in the neighborhood of 35 cents per ton. By approximately estimating the probable consumption, it is not difficult to determine how much if anything is to be gained by a location on a line of transportation. The disadvantages of a location a mile or so from the centre of consumption, in addition to the loss of time in traveling between the customers and the station (which is not inconsiderable), will be the loss of electric energy in overcoming the resistance of two miles of wire, say four ohms, which is nearly equal to the loss of a lamp on each circuit, and the cost of erecting and maintaining the circuit between the central station and the point where the lines diverge.

It is very apparent that the relative advantages are much in favor of central location, if suitable premises can be secured at a reasonable rent.

THE STATION BUILDING.

The site having been determined upon, we will next consider the character of the building to be erected. The structure may be of brick, or of wood covered with some non-combustible material, as slate or sheet-iron. The boiler room should be of ample size and so situated that coal dust cannot penetrate into the machine room. The lowest timbers of the roof should be at least eight feet above the top of the boilers, and there should be a passage way six feet in width between the rear of the boilers and the wall. Care should be taken that sufficient space is left in front to allow a flue cleaner to be easily handled. For example, if the boiler is 16 feet long, there should be at least 18 feet between the front of the boiler and the wall. It is a common practice to have the floor of the boiler room three feet or

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more below the ground surface probably for the convenience in accommodating a large coal heap. This plan may answer very well if only one sort of coal is used, but more recently much attention is being paid to economy in fuel, so that conveniences for weighing and mixing coal are desirable if not necessary. We therefore recommend making provision for a coal room adjoining the boiler room, both floors being on the same level. The supply of coal can be stored in this room and brought into the boiler room as required for use. It is desirable that the employés entrance to the boiler room should not be through the machine room.

In addition to the boiler, coal, and machine room, an office, a store room and a workshop are required. The location of the business office should be near the machine room but not in it. The workshop should be as far from the machine room as possible, as in the operation of testing lamps it is very important to have as little extraneous noise as possible. If high speed engines are used it is better to place the engines and machines in the same room. In arranging the machinery care should be taken to place the engines in such part of the room as will permit of the steam pipes being run as directly as possible from the boiler.

On the machine side of the room the ground should be removed to a depth of five feet, and a wall built around the four sides of the excavation. The floor is placed on strong beams supported by large brick pillars. This is important in order to have a dry and well insulated floor under the machines. It will be all the better if the floor is raised as much as 18 inches above the ground as the basement can then be utilized as a store room. The floor surrounding the engines should be of hard glazed brick or tile, so that it can be easily kept clean. That on which the machines stand must be of dry wood, and not a single nail visible at the surface. Have as many windows and ventilators in the machine room as possible, and the ceiling high, as it may be expected to be warm in summer.

On the roof of the machine room build a so-called "cupola" for leading in the wires. Let the machine and boiler rooms be constructed so that they can be enlarged if needed.

A 60 h. p. high speed engine with two 30 light dynamos covers a space 32 feet by 10 ; a slow speed engine with the necessary shafting and two dynamos can be set up within a space 25 feet by 20, but all depends on the arrangement of the shafting. A boiler which, using bituminous coal, will generate steam for an ordinary 80 h. p. engine, may occupy a space 9 feet by 20.

In small stations where slow speed engines are used, the engine may be in the same room with the machines as one man can then look after both. In large stations using slow speed engines, it is better to have the engines and the machines in separate rooms.

In planning a station of this description avoid having vertical belts. Horizontal belts are the easiest to run with, although they are rather inconvenient. Belts at an angle of 45° from the floor are more desirable as the attendants can pass under them.

The engine room should be parallel to and on a level with the machine room and the driving pulley should be fixed in the centre of the shaft. Then the belt of the engine pulls on one side, and the belts of the machines on the other, with the greatest strain on the shaft in the centre, decreasing towards the ends, which is the best arrangement.

SLOW *vs.* FAST SPEED ENGINES.

Having given an outline of the plan on which to erect a station, the next thing to be considered is the type of engine to be adopted.

Electric light people as well as other power users seem to be much divided on the engine question. Some are even more ardent advocates of slow speed engines than the makers themselves, others again pin their faith and fortunes to the high speed system. Practical experience seems to favor large slow speed engines for large stations, and small high speed engines for small stations. It is a great mistake to put all your eggs in one basket. Imagine a station trusting everything to a single source of power. An instance of this may be quoted. A station of upward of 400 lights had but one source of power; a very small part of the mechanism got out of order ; the whole of the lights run from that station were out for one night. This took place about a year ago. Supposing they had had an arrangement whereby half the lights could have been kept going how much better off they would have been. Consequently we are strongly of the opinion that it after all is not so much a question of which type is most economical, as which is most suitable. The manufacturers of slow speed engines, claim, and with justice, that their type of engines can be run with a small expenditure for fuel ; makers of high speed claim very much the same thing. It is apparent, however, that an engine making 300 revolutions per minute, will experience more friction during that minute than one making a hundred. This requires more oil and also necessitates closer attention for the high speed than for the slow. On the other hand the slow speed requires shafting, loose pulleys on the shaft of the dynamo, wide faced pulleys on the counter shaft, or, instead of these, friction clutch pulleys (which are decidedly preferable), so that the shafting perhaps takes up as much extra oil and attention as the high speed engine. The one is a set-off to some extent for the other. The relative consumption of steam in the two types can only be determined by very accurate and prolonged tests. The rate of consumption of coal has very little to do with such a test. The true test for an engine is not the quantity of coal consumed, but the quantity of water evaporated. It is the steam that runs the engine, steam results from the evaporation of water in the boiler, consequently the efficiency of the boiler has to be considered when it is asserted that only a certain amount of coal is required. Moreover, engines are built to carry a certain load under a given pressure of steam with maximum economy. The further this condition of affairs is departed from, the lower becomes the economy and efficiency of the plant. If the purchaser in ordering an engine says he wants a 50 h. p. engine, the maker will supply one which, with a given pressure of steam cutting off at the most advantageous point, will develop 50 h. p. If you carry a lower pressure of steam than that stipulated for, then you will use more of it, or if you try to get 60 h. p. or more out of it, you can only do so by using more steam ; on the other hand, an engine too large for your work will require more steam per horse power.

In making a comparison therefore of the two types of engines, not only have all these conditions to be very carefully attended to, but due regard must likewise be had to the condition of the atmosphere, the length, size, and covering of the steam pipes, and above all, the quantity of water evaporated, regardless of the quantity or quality of coal consumed. When it has been determined which type of engine requires the least amount of steam for a given load, the problem, in its commercial aspect, is not solved by any means. What an electric light engineer wants to know is this :—Out of which type of engine can I get from the same dynamo, a given number of ampères and volts, with the least evaporation of water. With slow speed engines we must allow not only for the friction of the engine itself, but for that of the shafting. Sometimes this will be found to run up to 15 per cent. even when the engine is running under the most favorable conditions. Of course allowance has to be made for the high speed engine also, but having no line of shafting, it will not bear as high a ratio to the power absorbed by the dynamo. What we are really trying to ascertain is this :—How much power can we get at the pulley of the dynamo with a high speed engine, belting direct, from a given quantity of water evaporated, and how much, other conditions remaining the same, with a slow speed engine transmitting power through a counter shaft.

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The two types of engine are simply methods of converting steam into ampères and volts by means of a dynamo. The quantity of coal required to produce that steam has nothing whatever to do with the engine question. It goes without saying, that the method requiring the least amount of steam is the most economical of fuel. Now let us suppose that the slow speed engine is found to use steam the most efficiently, the inference might be drawn that this type of engine should be used exclusively in electric light stations. Such however is not our opinion. Economy in fuel should be sought for most undoubtedly, but there are many other things to be considered. All stations must be prepared to give light to customers when they require it. Some require lights during the day, some early in the afternoon, others late at night, while some want it till daybreak. If you have not more than 200 lights, it is probable that not more than 20 of these are day lights. Will any one recommend running a 100 h. p. engine all day for the sake of supplying 20 lights? The friction of engine and shafting would require as much power as the lights, so that half of your coal would be consumed before you reached the pulley of the dynamo. With a small 50 h. p. high speed belting direct to the machine, these 20 lights could be run with far greater economy than with the larger engine. In a station of 400 lights and upwards, on the other hand, you would not be required to run for any length of time with so few lights, and in this case the large slow speed engines may be employed with advantage.

No station of any importance should be without a spare engine and spare machines. The spare engine should be of the same type and dimensions as those in active operation. If you desire to equip your station for continuous running and be prepared for every emergency, start in determined to have everything uniform. With 200 lights if you select two 100 h. p. engines, then your spare must be 100 h. p. Here you have standing idle 50% of what is running. Think of it. If you select four 50 h. p. engines, the spare one would be 50 h. p., only 25% of what is running.

If you anticipate having 600 lights, why not have five 150 h. p. engines, all of the same maker, and have the dynamos so arranged that you need never be under any apprehension of circuits being out.

Beyond all doubt small stations ought to be supplied with small engines and small machines, and large stations, with large engines and large machines. Begin with a good engine and keep to it. *Do not always be looking out for economy regardless of efficiency.*

The foregoing remarks have reference to single cylinder non-condensing automatic cut-off engines only, but where free water can be procured, the greatest economy in steam can be obtained by using condensers, more especially compound condensing engines. To secure free water for condensing purposes, you could afford to locate a station a considerable distance from the centre of consumption, because whatever the expense may be to get 100 h. p. out of a non-condensing engine, by adding a condenser you will get from 120 to 130 h. p. from the same steam, and by making use of a compound condensing engine you will indicate considerably more. Experienced engineers whose veracity is not to be doubted, say you will get close on 200 h.p., and even more.

Comparing the first cost of these types including condensers in position, with single cylinder non-condensing engine, we find that there would not be any material difference *per horse-power.* Suppose the requirement to be 200 h. p. There will be two 100 h. p. or one 200 h. p. engine, two boilers of 100 h. p. capacity each. With a compound condensing engine only one boiler would be required. The cost of the second boiler would nearly cover the difference in price between the two respective outfits. Compound condensing engines have not thus far met with a very favorable reception among our mills, factories, and workshops. One reason of this may be that free water is not always procurable, another reason may be that the cost of power required to run the machines bears such an insignificant proportion to the other expenses of the factory, that manufacturers have not given much attention to the subject—but we know for a fact that wherever a manufacturer has been persuaded to adopt good compound condensing engines, he has without exception been highly gratified with the results.

In electric light stations, power is a large item; the cost of the power in an electric light system has been estimated at 32 per cent. of the whole operating expenses. If the business of supplying power by means of electric motors should be taken up hereafter, as it will be, the cost of power will be nearly all there is to it. We all know that there is a material difference between the power developed at the driving wheel of the engine running the dynamo, and that obtained at the shaft of the motor; but if by adopting compound condensing engines, you can produce power 50% cheaper than the manufacturer himself can do it with his single cylinder non-condensing engine and antiquated boiler, you can, notwithstanding the loss on conversion through the dynamo and motor, sell him power cheaper than he can produce it. If the managers of electric light plants now using large non-condensing engines could only be fully persuaded of these facts, and go on and make the necessary changes, they would have very handsome results. The question of free water is not always difficult to overcome; in many situations artesian wells offer an easy and cheap solution.

Whatever type of engine you have, avoid coupling two of them together. It is obvious that when two engines are running on one shaft, and from any cause you have to stop running one of them, in order to disconnect the connecting rod, you must shut both down. Meantime where are your lights? Let each engine carry its own load, and when anything arises necessitating the stopping of one, get your spare engine and machines going, and then shut down. This can be done and your lights maintained without so much as a flicker. This is the only plan by which a continuous and reliable light can be maintained, and in the electric light business, as in every other, reliability is the ultimate criterion of permanent success.

With large engines comes the question of shafting. Friction clutch pulleys have been tried in some places and found wanting. Most people who use shafting admit that friction clutches are very desirable. The difficulty has been to get a clutch that would stand the strain. There are clutches now made which are equal to any strain the belt will transmit. Formerly the clutches which were made, trusted to the friction alone. Some of the latest and most improved clutches start by friction, but after getting up to speed they lock themselves and cannot possibly slip. In releasing them, the locking part is first disengaged, then the friction is removed. This form of clutch is the one which should be used in electric light stations. It is the safest and best. Loose pulleys on the armature shafts are better than nothing, but, as a matter of fact, it takes very little to convert a loose pulley into a tight one; besides with a loose pulley on the machine, the pulley on the counter shaft has to be twice the width of the belt, making a very heavy ponderous pulley and increasing the friction on the shaft bearings; and after all, the utmost you can do with the loose pulley, is to stop the machine from running. You dare not attempt to change the armature, indeed you have to be exceedingly careful while working around a machine with the belt running on the loose pulley, especially if you have a light and easy running machine, otherwise you will find the armature running, being driven by the friction of the loose pulley. Leaving the engines and shafting, we will next turn our attention to the boiler room.

(*To be continued.*)

COMBINED TABLE OF PRINCIPAL WIRE GAUGES.

Correction.—In column ix, page 183 of our May issue, the fraction $\frac{1}{64}$ should be two lines lower, opposite 15,625.

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DYNAMIC ELECTRICITY.

BY CARL HERING.

(Continued from page 186.)

CHAPTER III.

Magnetism and Electro-Magnetic Induction.

Among the different units and expressions used in representing and measuring magnetism and magnetic forces, and the laws by which these are governed, the most important are the following.

Lines of force are units in terms of which magnetism may be expressed and measured. A magnetic field which is nothing more than a space in which magnetism exists, may be said to contain lines of force. The direction and polarity of these, indicate the direction and polarity of the magnetic force; their total number is a measure of the amount of magnetism; while the number per square inch of area, measured perpendicularly to their direction, is a measure of the intensity of magnetism at that point.

This conception of magnetic force may perhaps be better understood if compared to the force of gravity similarly represented. Imagine a heavy body suspended in the air, and suppose every cubic inch of the material of which the body is composed, to weigh one pound. If an imaginary line be drawn to the earth from the centre of gravity of each cubic inch of the suspended body, the direction of these lines would represent the direction of the force of gravity; their total number would represent the total force in pounds, while their density, or the number of lines per square inch area (measured perpendicularly to their direction) would represent the intensity of the force at that point. In precisely the same way as these lines represent the direction, amount, and intensity of the force of gravity in that body, so do the lines of magnetic force represent the direction, amount, and intensity of magnetism, except that in the latter there is no constant direction of action such as the downward force of gravity, lines of force acting in both directions as if trying to shorten their circuit, like a stretched rubber ring. The lines do not exist as such, any more than they do in the analogy of the force of gravity, it is merely a convenient way of representing magnetism in order to facilitate the conception and computation of problems.

The *amount or quantity of magnetism* is therefore expressed by the total number of lines of force. *Magnetic density, or intensity of magnetism* is expressed by the number of lines of force per square inch area measured perpendicularly to their direction. The *polarity* of a magnet or a magnetic field, is represented by the *direction* of the lines of force (indicated by arrow heads), as distinguished from their *position*. The *axis* of magnetization is a line parallel to the path of the lines of force.

A single line of force, or unit, is that amount of magnetism which passes through every square centimetre of cross section of a magnetic field whose intensity is unity. Such a magnetic field exists at the centre of curvature of an arc of a circle, whose radius is one centimetre, and whose length is also one centimetre, when a current of 10 ampères flows through this arc. Or, stated in the language of the practical electrician, it is the amount of magnetism which passes through an area of one square centimetre, at the centre of a coil of one turn, having a diameter of 10 centimetres, when a current of about eight ampères (accurately 7.9578) flows through the wire. As the intensity in every part of the area enclosed by the circular coil is the same,[1] it follows that one line of force will pass through every square centimetre of this area, or altogether there will be 78.54 lines of force evenly distributed in the space enclosed by the circle. The earth's magnetism is a uniform field of this character, whose intensity in the direction of the "dip" may be represented by about .5, which means that through every square centimetre measured perpendicular to the direction of magnetization, ½ of a line of force passes, or in other words, through every two square centimetres one line of force passes.

1. This follows from a law given by Maxwell.

The *direction* assumed for lines of force (generally indicated by arrows), as distinguished from their *position*, is, of course, arbitrary, as they have no such direction of action, as mentioned before, but in practice it is very convenient for defining terms and for stating laws, to concede them to have a certain direction, and it has become universal to consider them as emanating from the north pole of a magnet and entering the south pole, as shown in figure 1. Thus the direction of the lines of force in any magnetic field would be the direction in which a magnetic

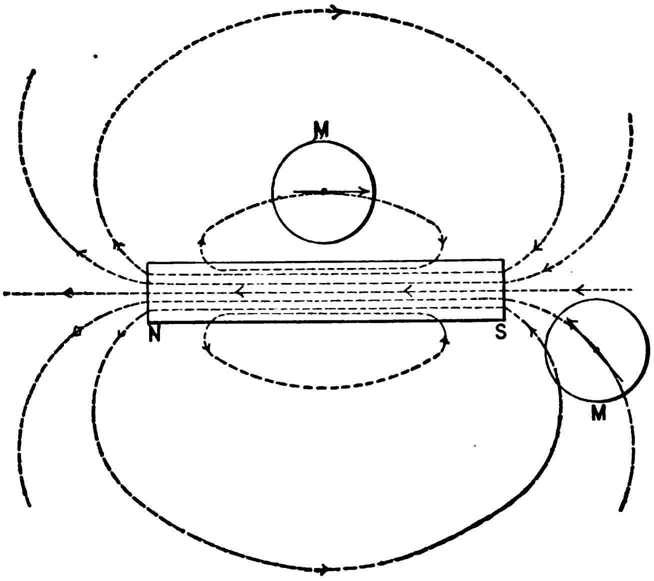

FIGURE 1.

needle M, figure 1, points, if made as usual, in the form of an arrow having the point at the north (north seeking) end.

An electric current is always surrounded by lines of force which encircle it, their density decreasing as their distance from the current increases, as shown in figure 2. Assuming that the lines of force have a direction as just described, then *if the current flows away from the observer, the line of force will pass around in the same direction*

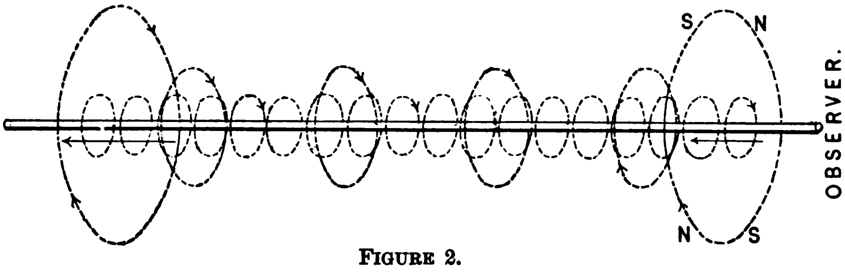

FIGURE 2.

as that of the hands of a watch, as will be seen in figure 2. In other words, below the wire the north pole will be to the left and the south pole to the right, while the reverse is the case above the wire.

From this the laws of the polarity of electro-magnets follow. In looking *at the face of the pole, if the current flows in the direction of the hands of a watch, it will be a south pole, and if in the other direction it will be a north pole*, as illustrated in figure 3, which shows some of the lines of force encircling the wires of the coil and condensing in the poles of the magnet. This rule is easily remembered, as it is the same direction as that of the rotation of the earth in looking at its geographic north and south poles from a point in space.

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Lines of force which have the same direction repel each other, while if they have opposite directions they attract each other. This explains why like currents of electricity attract, and unlike repel each other, as will be seen in figure 4, in which two like and two unlike currents are shown with some of their lines of force encircling them; in the first two the neighboring lines of force are unlike, in the last two they are like.

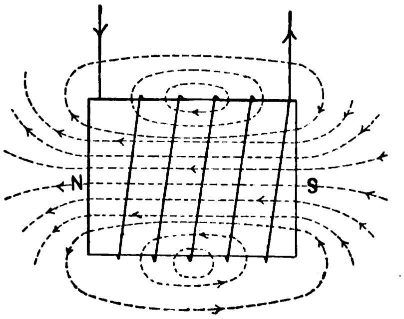

FIGURE 3.

The following properties of lines of force and of magnets, will frequently be found useful in designing machine magnets. Every line of force makes a complete closed circuit, that is, it emanates from a north pole, passes through the field around to the south pole and returns to the north pole again through the magnet. From this it follows that the number of lines of force is the same in all the cross sections of their complete circuit, and therefore the intensity of a field is inversely proportional to its cross section if it is uniform, showing that the most intense field is in the iron of the magnet where it cannot be utilized. It also follows

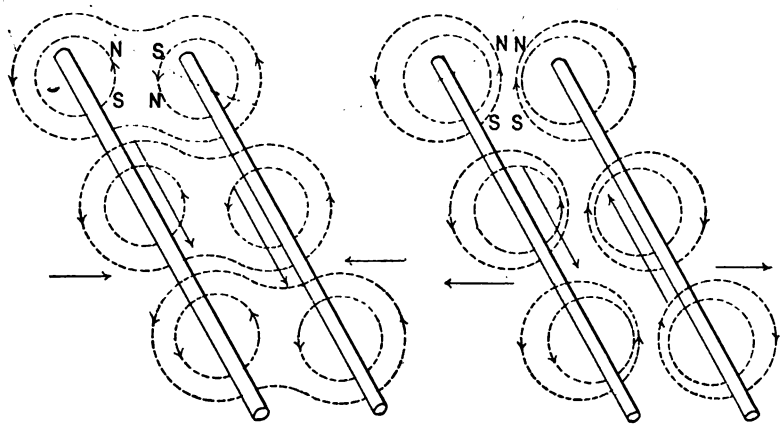

FIGURE 4.

from this that around a single pole the intensity of the field (number of lines of force per unit area) diminishes as the square of the distance to the pole.

Magnetic materials readily conduct and, therefore, also condense in them, lines of force[2] while non-magnetic materials offer great resistance to them.

In applying these properties of lines of force to dynamos, it follows that all the parts of their circuit should offer the least possible resistance to them. For instance in the Weston type of frame, with four coils, the cross section of the end pieces should be at least equal to that of the core of a magnet; that of the pole pieces measured perpendicularly to the direction of the lines of force, should be at least double that of a core; the iron of the armature, measured horizontally should have at least twice the cross section of a core, if it were made of the same material; and as the space between the armature and pole pieces offers the greatest resistance, it should be made as short as possible in the direction of the lines of force and have as large a cross section perpendicular to this direction, as other considerations will permit. The average thickness of this space may be reduced by projecting iron lugs between the wires (like in a Pacinotti ring armature as distinguished from a Gramme), which S. P. Thompson has shown increases the effect.[3]

In regard to the magnetic properties of wrought and cast-iron, a certain authority states that for the same coil and current the magnetism of a wrought iron core is 30 per cent. greater than that of a cast iron one. From this it follows that if the cost of the wire and iron of a 30 per cent. larger cast iron magnet is less than that of the smaller wrought iron one of equal strength, then the former should be used, notwithstanding its increased size and its poorer magnetic properties. The relative cost of wrought iron and cast iron magnets depends evidently on the style of the frame of the machine. S. P. Thompson states that a cast iron magnet has only 60 per cent. of the effect of a wrought iron one of the same size. He also states that the permeability of iron to magnetic lines of force is from 40 to 20,000 times that of the air, from which it would follow that the cross section of an air space in the circuit of the lines of force, measured perpendicularly to them, would have to be 40 to 20,000 times that of the iron to offer the same relative magnetic resistance.

Lines of force can never intersect each other; when a number act at the same point, in different directions (as in a galvanometer in the earth's field, or in the combined field of an armature and its field magnets), their total action will be represented in intensity and direction by their single resultants. If such a resultant is allowed to act, as in the case of a magnetic needle containing fixed lines of force in it, suspended so as to be free to move, then the effect will be to move the needle until this resultant passes through the centre at which the needle is suspended. This illustrates the law that lines of force strive to arrange themselves parallel to one another.

Lines of force act as though they were elastic, tending to make their complete circuit as short as possible, and exerting a lateral repelling force upon one another, thus tending to equalize the magnetic density in a homogeneous medium. The resultant of these two actions at different points determines their position and density, as illustrated in the field around a bar magnet by the well-known experiment of throwing iron filings on a glass plate covering the magnet.

Some of the general laws of electro-magnetic induction are as follows:

The electromotive force generated by moving a conductor in a magnetic field, is proportional to the number of lines of force cut per second or to the rate of cutting lines of force. It therefore increases with the speed of the moving wire and with the number of lines of force cut, but not with the size of the field passed through per second without increasing at the same time the total number of lines of force. It follows from this that the greatest effect is produced by cutting them perpendicularly, for then the number passed through in the same distance of motion is greatest. It also follows that moving the conductor in the direction of the lines of force generates no potential, as in that case none are cut.

By definition, one volt electromotive force is generated for every 100,000,000 lines of force cut per second, or in other words, the electromotive force in volts generated in the inductor is equal to the total number of lines of force cut, divided by 100,000,000 and by the time in seconds in which it passes through them.

The direction of the motion in motors, or the direction of the current in generators, may be determined by the

2. It is claimed by some that iron merely conducts and condenses magnetism, but has no inherent magnetism of its own. It is very doubtful whether this last statement is correct.

3. *Dynamo Electric Machinery*, 1st edition, p. 66–69.

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following "rules of thumb," which are more practical and often less awkward in their application than Ampère's well-known rule of "swimming in the current."

In the conditions of Oersted's experiment the letters of the word *NOSE* give the initial letters of the principal words of the rule "If the current passes from the *N*orth pole *O*ver the needle to the *S*outh, the deflection of the north end will be toward the *E*ast." Similarly the word *SNOW* is the key to the rule "If the current flows from the *S*outh to the *N*orth *O*ver the needle, the north end will be deflected toward the *W*est."

In applying these rules to generators it need only be remembered that if the inductor be moved near the magnet, the current induced will be in the opposite direction to that which would produce this same motion.

A still better practical rule, and one which is very easily remembered is illustrated in figure 5. If a north pole of a magnet be grasped in the right hand, as illustrated, and

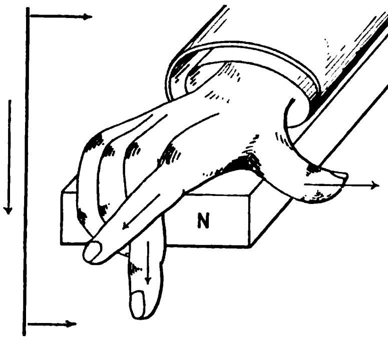

FIGURE 5.

the three fingers of the hand be held in the position shown, then the fore finger will point in the direction of the lines of force, which are assumed to emanate from a north pole; and if the thumb points in the direction of motion of the inductor or moving wire, that is, perpendicular to the lines of force, the third finger will then point in the direction in which the current will tend to flow under these conditions. In other words, if a wire be moved past a north pole in the direction in which the thumb points, the induced current will tend to flow in the direction in which the third finger points. This is called Fleming's rule. In this as well as in the other rules, it is evident that if one of the conditions be reversed, then the current, or the motion, as the case may be, will be in the opposite direction, while if two conditions be reversed, the current or the motion will be in the same direction. For instance, if a north pole be grasped similarly in the left hand it will give the conditions of a motor or of Oersted's experiment, the thumb in that case pointing in the direction of the motion which the wire (not the magnet) will have if the current in it flows in the direction as indicated by the third finger.

In connection with the above rules it must be remembered, as before pointed out, that it is the electromotive force and not the current which is induced, and that, therefore, the electric polarity of such a wire in which induction takes place, is the *reverse* of what it would have to be to cause that current to flow through the conductor. In other words, as the positive pole of the inductor is the one *out of* which the current tends to flow, it follows that the current in the inductor itself flows from its negative to its positive pole, just as in a battery in which the current in the liquid flows from the negative (zinc pole) to the positive (copper or carbon) pole, and not from the positive to the negative as in the external circuit.

It follows from the above laws that with a magnetic field of a certain strength, and a moving inductor having a given speed and position in the field, a certain definite electromotive force will be generated which is quite independent of the resistance of the circuit. From Ohm's law it follows that any desired current can be generated with a certain electromotive force as it depends only on the resistance. Therefore, it is evident that any desired current can be generated with a given magnet and a given speed of motion and position of the inductor, or in other words the current is not directly dependent in either the magnet or the speed, but is the quotient of the electromotive force divided by the total resistance, the latter quantity being in most cases a variable one.

In one sense, however, the electromotive force in an electric machine as distinguished from batteries, is to a certain extent dependent indirectly on the current, for when it flows in the inductor it tends in all cases to oppose or weaken the magnet, and therefore indirectly affects the electromotive force. In other words the counter-magnetism of the armature of a machine tends to weaken the field, hence the practical rule: Make the magnetism of the field as strong as possible, and the counter-magnetism of the armature as weak as possible, which is done by making the number of windings on the armature as small as possible.

It may be well to call attention here to a distinction between the terms "electromotive force" and "difference of potential," which it is very desirable to adhere to as strictly in English as is done in the French and German languages, as it often aids greatly in clearness of statement. Difference of potential, is, as the name implies, the difference of the electrical potential at any two points of a circuit, and may therefore be applied to that at the poles of a machine, battery, or lamp, or at the ends of leads, or in general to any two points in a circuit. The term "electromotive force," however, applies only to the maximum difference of potential which exists in the circuit, or in other words, the total generated difference of potential. It applies, therefore, only to the generators of differences of potential, such as machines or batteries and to counter or opposing differences of potential developed in motors, arc lamps, or in the charging of secondary batteries. The available difference of potential at the poles of a generator is therefore its electromotive force, less that which is absorbed by the internal resistance of the generator, and which according to Ohm's law is dependent on the current, while the electromotive force is not dependent on the current (except indirectly as mentioned above, as in the case of machines or in polarizing batteries). In generators the two are equal when measured on open circuit, with an electrometer or any other instrument in which no current needs to flow.

(*To be continued.*)

THE PATENT OFFICE AND PATENT OFFICE PRACTICE.[1]

BY A. C. FOWLER.

At the request of the council of the Institute, the following paper has been prepared.

At first I was at a loss to know why I had been called upon to write something on this subject, thinking that this would be assigned to some older member of this society, who had been longer in practice before the patent office; but the honorable secretary informed me that I had been called upon because of my experience as an examiner in the patent office, and especially in the electrical division, and could handle the subject from the standpoint of an examiner as well now as an attorney (although one of several months standing only), and could express myself freely inasmuch as I had now severed my connection with the patent office.

It was my intention a month ago upon receiving the invitation, to give the subject much thought and attention; to compile statistics and to review decisions at some length; but I regret to say that the pressure of business has compelled me to abandon such an undertaking, and to content

1. Read before the American Institute of Electrical Engineers, May 19, 1886.

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myself with making some observations on this subject which I trust will prove of interest.

One of the first things desirable, indeed we may say imperative about any practice in whatever jurisdiction, whether it be in equity, at common law, or before the patent office, is stability. I have several times heard lawyers remark that they could get along all right in the courts, but that the patent office was too much for them. It is often remarked that courts adhere too much to old forms and to old practice. The advantage of this is upon a little reflection readily seen; you always know where you stand; you know that the practice to-morrow will be the same as to-day. You are not told in a decision to-day that process and apparatus can be claimed in the same case, and by another decision to-morrow that this cannot be done. Under a decision to-day you are not given all information necessary to go into interference with a pending application if you choose, and by a decision rendered another year, all information whatever concerning an interfering case is withheld from you. Nor would you have to submit to such a thing as a strict interpretation of the statutes and rules regarding interferences one year and loose interpretation another year. Nor would an oath that was formal one year be declared informal the next. Nor would you have to limit your claims to "*means as described*" by the practice one month, and by the practice a few months later find that you are not required to so limit them. Nor would you be harassed and annoyed by startling innovations every month or so by an issue or draftsmans' division. By such a practice you never know where you are, nor whether you will be in the same predicament to-morrow that you are to-day.

So you see there is some advantage in having a practice and a law like the old unwritten common law and practice that has been handed down to us by England, and extends back to a time whereof the memory of man runs not to the contrary.

Under such a practice an attorney always has the law and the practice within easy grasp. He is always competent to advise his client. The practice is uniform and unvarying to a great extent. The practice of the patent office on the other hand is irregular and unstable. I say these things not to cast any reflection upon the officers of that bureau, nor to disparage the work done by this office, for I have the highest regard for them and for the arduous duty performed by them; nor am I unmindful of the serious disadvantages under which they labor. Neither would I be understood as not favoring progress and the removal of bad and unjust rules and laws in regard to patents, and the improving of the patent office practice by establishing new rules and precedents and by rescinding and overruling bad ones; at the same time I cannot help but think that the patent office practice needs reforming, and that more stability of practice would be one of the greatest steps towards this.

There is another thing in which the patent office appears to excel, and that is—the facility with which one tribunal or examiner overrules another. There is I believe nobody having judicial functions in which opinions and decisions are so often reversed and overruled—so little regard for precedents. The want of concurrent decisions in the patent office appears to be remarkable. This tendency to reverse is so marked that some of its officers have been known to sometimes overrule the U. S. supreme court. It may be that this is to be looked for where there are so many questions of fact, as well as so many questions of law and practice, with so many tribunals to take cognizance of the facts, interpret the law and decisions, and administer the remedy.

The want of stability of the patent office practice above referred to, it appears, results from several causes:

First. There are so many independent tribunals or heads to interpret the law and decisions.

Second. Some of those who are called upon to interpret the law and to apply the decisions fail to discriminate legally, but apply decisions alike to all states of fact, whether a different state of facts exist or not. To act judicially and to apply decisions and decide questions involving legal points, one must, of course, be legally equipped to some extent and possess a certain legal inclination, and be capable of making nice distinctions, so as not to apply decisions and rules indiscriminately and misapply references. So that an examiner should be something in a judicial way as well as a man versed in the arts and sciences. Some of of them are undoubtedly too narrow and illiberal, and should broaden their ideas a little. Some of them seem to act as if they were placed in their positions by the government not to grant patents, but to antagonize and harass inventors. These examiners act upon the principle, which is contrary to the legal maxim, that it is better to let ninety and nine meritorious cases suffer than to let one unmeritorious one pass. The question with these examiners is not *how to do* but *how* NOT *to do.* They forget that they are placed where they are by the government to facilitate and expedite matters—not to impede and obstruct—and that they are there to grant patents, rather than not to grant them. Of course a case should have a rigid examination and not a lax one—for the better, the more thorough the examination, the better for all parties concerned.

Third. Many of those in responsible positions have not had sufficient time to become versed either in the patent law, the practice or the arts. This results from the fact that many resign to go into practice in the various arts in which they become proficient in the patent office, owing to the fact that the government does not pay them enough to retain them, and they seek a field wherein they can make more. It is rare that a commissioner remains at the head of this department over a few years. He is called upon to act judicially as well as ministerially, but does not remain long enough to become well acquainted with the law or practice. The salary of this officer should certainly be increased considerably over $5,000, his present salary. He has so much to do of an executive nature that he has not sufficient time for judicial acts. The latter should no doubt be taken from him by statute, and be made to devolve upon some other person or tribunal appointed for this purpose. By this means the practice of the patent office would be rendered more stable. All the examiners in the office should then be required to adopt the rulings and decisions rendered by this tribunal, instead of interpolating their own ideas and making their own precedents.

Politics, which is generally in the interest of the few and not of the many, also operates against the efficiency of the patent office. I know of no bureau under the government, however, that is freer from the plague of politics than this one; yet politics does militate against it in more ways than one.

Of recent years examinations for promotion have been abolished, but I am happy to say within the last month they have been revived. While competitive examinations are not an absolute test of a man's capability and efficiency, they have proved to be the best system for the patent office. It was urged during the existence of the competitive examinations for promotion that the examiners spent much of their time studying up, to the detriment of the service. Since competitive examinations have been abolished they have wasted more time trying to get promoted. By the first system what the man gained by studying up was gained by the office, but by the scramble-for-promotion system the man gained nothing that benefited the office; in fact the office lost, for this system of promotion which did not investigate the merits of men, could not be a test of fitness. The patent office, however, has always held competitive examinations for appointment to the examining corps, and of recent years graduates of scientific schools and scientific men generally have been notified of such examinations in order to give them a chance to com-

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pete. By this system the examining corps has been recruited from men who are well fitted to fill these positions.

Many however, have been given positions in the examining corps within several years past, contrary to precedents and without examination. The method of doing this has been to give the person a position as laborer in the department, or some other minor position, requiring no examination for appointment, and inasmuch as there is no rule or law governing promotions, to promote the aforesaid person in a few months to an assistant examiner. So that where many of scientific attainments have been turned away because not able to pass the rigorous examinations for appointment, these favored few have crept in.

The question is :—How can these evils be eradicated; how can the system be improved and how can the rapidly changing personnel of the examining corps be made more permanent. The last can only be done by raising the salaries of the examiners. A principal examiner gets but $2,400, and his first assistant but $1,800, and so on down. How can this office hope to keep men who are expected to know the law and to be versed in the arts and sciences at such salaries? These matters can only be reached by congress and congress can only be reached by votes. Those of you who are interested in these and kindred questions concerning the patent office and the patent practice, as well as all manufacturers who are interested in patents, should demand of your representatives and senators that these evils be remedied. Make it a question of votes and you will accomplish something. The average official life of an examiner in the electrical division is rarely over three years, and as soon as he becomes skilled in this art he seeks a more remunerative occupation. This division is subject to more changes by reason of resignations than any other.

By carefully conducted but not too rigorous competitive examinations upon technological and scientific subjects, and the exercise of good judgment, for admission to the corps, and an examination upon these same topics and the law and practice for promotion, only those will reach responsible positions who are qualified to answer all requirements, and must therefore give satisfaction.

The patent office ever since its establishment has been, as you all know, a self-supporting institution. Being so it is difficult to understand why it is treated so niggardly by congress. The reason is, because you have not made it a question of votes. It is in fact more than a self-supporting institution. Out of the patent fund has been built one of the largest and most imposing buildings in Washington, ostensibly for the patent office; but this office is permitted only to occupy a small portion of this building, the major portion of it being occupied by the interior department and its other bureaus, which have never paid anything to the patent office or the patent fund for the use of this building. This office occupies the most undesirable portion of the building, and is hampered in its work by being overcrowded and the health of its employés seriously endangered thereby. The patent office owning all the patent office building should have as much room as it needs in this building, and congress ought to see to it that the bureaus of the interior department which are located in it and take up the room needed by the patent office, be required to move into quarters of their own, provided for this purpose.

Why should inventors be taxed for the benefit of the other bureaus of the interior department? Why should there be a surplus of receipts over expenditures each year in this office? Should not the money received by the government for a given purpose, be expended for that purpose? Should not all the money received for the patent bureau, be expended for this bureau and for the good of the service and not diverted from its purpose? There is only one answer to these questions, and the government acts in bad faith when it receives money for one purpose and expends it for another. You are aware, perhaps, that the electrical division has no electrical appliances to speak of, with which to test apparatus. They have asked and asked again for a laboratory, but in vain. Every division in the office needs men, needs facilities, needs everything.

The patent office is said to have to its credit, in the treasury of the United States, about $3,000,000. It has been proposed by congress to appropriate this surplus for educational purposes. While it could not be diverted to a better purpose there is no reason why all of this fund should be used for the above purpose. I am told that some years ago, an assistant commissioner investigated this question of the surplus of the patent office, and found that as a matter of fact, if due allowance had been made in years gone by for printing done for this office by the government printing office at public expense, that this would about offset the surplus of three millions. This money of course had to be appropriated by congress for the printing office, and in this way congress was really making appropriations for the patent office through the government printing office. In recent years the cost of all the printing done for the patent office by the printing office has been deducted from the patent office receipts, but even now there is a large surplus of receipts over expenditures every year, which in some years has amounted to several hundreds of thousands of dollars. So you see that the patent office formerly was about self-supporting only, but of recent years is more than self-supporting. Now if the interior department had allowed the patent office anything for rent of its building, the patent office would nevertheless have a large surplus to its credit in the treasury; but if all the money now received be expended for the patent office, so as to make the expenditures equal to the receipts, you should feel satisfied, as the service would by this means be very much improved.

Either this should be done or the patent fees should be reduced, for by the present system the government is imposing a tax on inventors, which, I take it, was never intended to be done. The idea of taxing patents is a foreign one to us. It is the course pursued by foreign countries, and tends to check invention and deter inventors from taking out patents. This is attested by the growth of inventions and patent interests in this country, which exceed by far those of any other nation in the world. It is not that American inventors are more ingenious than those of other countries, but because the inventors are not taxed as they are in other countries. A tax upon the patentee was never intended by law. A patent is in no sense a monopoly.

The fees for patents in this country are surely small enough, and every inventor, I think, would be glad to have them remain as they are, if all the fees were paid out for the good of the service. It is the salaries of the examiners which should be increased.

Now then, you say, suppose the American system remains as it is, what is going to become of it? The chances are that it will go along as it is, unless some steps be taken by you and all of us to prevent it. Each day the examinations in the patent office are becoming more a matter of form and less a matter upon the merits. This cannot be helped with the amount of work on hand and the force to do it. Every day our patent system is becoming more like the English system and the systems in other foreign countries, where no examination on the merits is made, and where a patent gives you no *prima facie* right to the thing patented. The distinctive features of our system are rapidly passing away, and it will not be long before the patent office examinations will be formal only, and our patents will have to be sustained in the courts before they are worth anything. Every day less and less importance is attached to a patent in this country. This rapid approach of the American system to the English and other systems will go on until the patent office gets to be but a mere registration office.

The tendency of this will be to increase the business of solicitors and patent lawyers. The former will be called upon under this system to make the examination on the merits, which was formerly done by the office, and draw

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up the papers in accordance therewith, and the patent lawyers will have more suits to bring; so that this system will bring advantages to some but will be disadvantageous to others. On the other hand, capitalists will be slow to take hold of or buy up inventions, and thus the patent interest will suffer to a marked extent. For one, I shall be very sorry to see such a change.

Regarding the value of caveats, it may be said that they are practically of no use. I generally advise those who ask my opinion, notwithstanding it is prejudicial to business, not to apply for a caveat. A sketch of an invention, with perhaps a short description and a witness or two, in the hands of the inventor will afford as much protection as a caveat. As a matter of fact, but little attention is paid to caveats by the office, and they are often overlooked. I only remember having notified one caveator to complete his invention during my experience of over five years in the examining corps, and then after he had completed his invention within the three months allowed, it was totally different from the other party's. This is about the only instance in which the patent office takes your money and does not give you an equivalent. It seems that the law relating to caveats could very properly be repealed. They cannot in any way prevent an interference, and inasmuch as you can go into interference with a case just as well after it has been patented, you can see that a duly witnessed sketch establishes your date just as effectively as a caveat, and does not cost ten dollars.

It is encouraging to note that reissues in the courts and in the patent office are beginning to be looked upon with more favor. The decisions in the Giant Powder Company *vs.* the Vigorit Power Company, James *vs.* Campbell, Miller *vs.* Brass Company and others, went to about as great an extreme in one direction as did the patent office formerly in the other in granting reissues. There is, no doubt, a middle ground upon which they can safely rest. The question as to the advisability of reissuing is one requiring much thought, and can never be absolutely free from doubt. It does not appear to depend solely upon the time elapsing between the discovery of the mistake and the time the reissue is applied for. Of course laches is taken into consideration, but the question depends somewhat upon whether intervening rights have accrued in the meantime. Where none have accrued, and the time is not unreasonable, the question is easily settled.

The question of interference is a perplexing one to many, but the proposition is a simple one. The one first to conceive is entitled to the patent, *provided* he is using reasonable diligence to perfect his invention. It of course makes no difference whether another perfects the invention first, as long as you are the first to conceive and are using reasonable diligence. Neither does it, of course, make any difference whether the other party has obtained a patent, for it is invalid if you were the first to conceive and have been diligent. Whether the old system of interferences is better than the present system is a question upon which a good deal can be said on both sides. Parties now, as you well know, are not placed in interference until they claim the same subject-matter. Previously when one party made a claim that the other one could make, but who only showed and described the subject-matter, the former was notified of the other's claim, and given a certain time within which to amend his claims if he chose. By the system now in vogue many cases go to patent which ought, as a matter of fact, to go into interference, instead of giving a patent on substantially the same thing to each party because they did not claim exactly the same subject-matter. So you see by this system a great many patents are now issued which show and describe the same subject-matter, and thus a confusion arises, and this casts odium upon patents. By the old system a bad attorney, who did not know how, or take pains to claim the invention properly, got the benefit of a good attorney's work; besides, people are supposed to know what they have invented, and they are at liberty to claim what they wish, and this is their own lookout. The present system was inaugurated a few years ago, at a time when the interference division was overrun with interferences, and this course, it is said, was adopted to relieve this division. Since its adoption the number of interferences has decreased materially, and cases are often now held by the office for months waiting for parties to claim the same subject-matter. The office, however, is now very liberal in construing the rules relating to interferences in view of certain decisions, and claims under the new system are now placed in interference whenever they can be construed to cover the same subject-matter. But even under this practice many cases go to patent which should in reality be placed in interference. Of the two systems, therefore, it seems that the old system is preferable.

The decisions in *ex parte* Blythe, which held that process and machine could not be claimed in one and the same case, as you may be aware, has been overruled. This indeed is a step in the right direction; for this decision brought about some absurd results. The test in these cases as to whether a process and product or machine can be joined in one application is: whether they are inseparable, that is to say, if the product can only be produced by the process or method, and no other process or method is known by which the product can be produced, then they can be joined in the same case. So too, if the process or method is inseparable from the machine and the working of the latter carries out the former, and no other means are known by which the method could be effected, they can be allowed in the same application. Of course the method must be something more than the mere necessary operation of the machine. So where a machine produces a product and no other machine or method is known by which the article can be produced, it can be claimed in one and the same case with the machine. So too where the method, machine and product are inseparable as pointed out, they can be joined in the same case.

Just what a method is, is difficult to say. The term is used as synonymous with process, but the word "method" refers generally to mechanical processes or operations. A method has never been clearly and fully defined, and whether a claim is for a method, or for the operation of a machine, or whether in fact it be a method at all, are matters upon which there is much diversity of opinion. Some say method claims should be wholly independent of any means, and not limited by the means whereby the method is accomplished, but this must be received with some allowance; for it is well-nigh impossible to draw a method claim without specifying some means. Some say on the other hand, that a method claim cannot cover anything that is automatic. That as soon as you introduce the word "automatic," in a method claim, that it becomes in whole or in part a claim for the operation of a machine; for they hold that whatever is automatic depends upon the machine itself and does not depend for its operation upon the exercise of thought or volition, and hence cannot be said to be within the term "art" used in the statute. It is difficult to say whether this is to be accepted, and in some cases it is not seen how it can be received. These method claims are very much in vogue just now, and as electricity is known and defined by its functions only, and as it is difficult to define sometimes an electrical invention in any other way than by its functions, the method claim is very common in the electrical division. These claims certainly come nearer covering principles of operation and functions than any others that are allowed. Some also go so far as to say that there can be no such thing as a joint invention, and they hold the idea of joint inventorship, as a matter of fact, an absurdity.

To tell what the office considers a functional claim is difficult, sometimes it's one thing—sometimes another. It is granted, of course, that where elements of the combination are specified, and their functions added, that this does

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not render the claim functional; but where there are all functions and no means, or where a result is specified without stating any means, or sufficient means, the claim may be said to be functional, although the latter is said sometimes to be a claim for a result. I think it will be admitted that the nearer you come to claiming the function or the principle of operation of your invention, the better you are protected. In fact, to claim a thing functionally is the easiest and clearest way of defining an invention, but since this is not permissible, one must content himself by protecting his invention as best he can. Under the German system it is deemed advisable to make the claims few and functional, and, as you well know, they hold very strict examinations there, and concerning questions of patentability and matters of form are very particular.

How to claim an invention is a question. The claims as you know are the vital part of a patent. You are well aware if a man describes and shows a dynamo machine in his patent but only claims the commutator that the patent is good only for the commutator, so you see a man may invent, describe and show a very good invention but claim a very poor one. Whether a few claims will do or whether many would be better is a question. It is always safe, however, to err on the right side, and it seems that claims ought to be drawn somewhat like the counts to an indictment; so that where you fail as to one, you may prevail as to another. It seems to be a good plan to draw your claims as broad as possible, and then to put in claims a little narrower and so on down, until you reach the exact construction of your apparatus, so that should it happen that some of your claims are too broad or do not interfere with the claims of a pending application even you can rely or fall back on the remaining ones. The graduating of claims in this way seems almost a necessity. It is not meant by this that claims should be unnecessarily multiplied or too numerous, yet redundancy, you know, does not vitiate.

There is another thing, and that is, you must not accept every rejection of the patent office as a good one. The spirit of acquiescence must not be too strongly marked in you, else you will not get what you deserve. On the other hand, you must not waste time unnecessarily antagonizing examiners and wrangling over small and unimportant points. You must fight, but you must fight for something.

The examiners of the patent office are often censured by patentees and assignees of unexpired patents for granting certain patents. These persons are continually finding fault because subsequent patents have been granted which conflict with their patents. These parties make a mistake that is often made, that is, they do not distinguish between patentability and infringement. The patent office deals with questions of patentability only. It is not the duty of examiners to pass upon the question as to whether a subsequent patent is tributary to your prior patent, or whether it is an infringement, or whether a claim is broad enough to include a subsequent one. They decide whether there are any substantial differences and whether these differences are new and useful, not whether the subsequent patentee has to make use of your invention before he can use his own embodying these differences. A thing, of course, may be patentable, and yet an infringement. The courts only deal with both of these questions.

The limiting of patents to expire with the expiration of the first expiring foreign patent previously granted is a section of the law that still remains unrepealed, although much has been written and said on this subject. There is no reason why this limitation should exist, and it should therefore be removed.

The question often arises when is the best time to sell an invention or patent right. This time is, I think, while it is pending in the office, after the case has been allowed, and when it is yet in the issue. An invention at this time seems to command more respect and a better price than at any other time. It seems at this time to be surrounded by a halo as it were, and as soon as it becomes public by reason of patenting, it seems to lose in value and respect. Before the case is allowed there is doubt about its being allowed, but when it is allowed, you know that as soon as you pay your twenty dollars you can have a patent. At this time also it is best to apply for your foreign patents, and you have six months after this in which to do it, as you know.

One is often in doubt whether it is safe to exhibit an invention before patenting. Experience in the office and in the interference division has taught me that interferences between independent and original inventors are rare. They are generally between employer and employé, or between men working in the same shop, or between those who have in some way seen or got an inkling of another's invention. There is of course some risk assumed in exhibiting an invention while in the issue, but not a great deal; here you have the matter to some extent within your own control, for as soon as you find out that some other party is inventing in your line, you can pay your final fee and your application will go to patent. Before the case reaches the issue you of course do not know whether you can get it through or how long it will take you to do so, and it is therefore not safe to show the invention at this time except to reliable parties. Interferences, I suppose, are as frequent, if not more frequent, in the electrical division than in any other. Inventors in this line seem to exhaust one field and then take up another. Each watches what the other is doing and keeps pace with the literature on the subject, which often directs them in the same channel.

Not more than ten years ago the electrical division was a small portion of the division of measuring of philosophical instruments. To-day it is about twice as large as almost any other division, employing in all nine examiners: one on dynamos, motors and regulators, one on locomotion, telephone systems and calls, one on telephones, one on telegraphs, another on arc lights, another on incandescent lamps and systems, still another on batteries (primary and secondary) and alarms, and two on miscellaneous classes. Until within not many years ago telegraphy in one form or another constituted almost the whole class of electricity. The number of inventions in this latter class has been steady from the first and holds its own to-day. The applications for arc lamps were at one time very numerous, but have now fallen off. Secondary batteries with which the office was at one time flooded have now fallen off to almost nothing. Invention in dynamos, regulators, telephones and incandescent lamps is steady; while motors and locomotion appear to exceed all others just now. The various methods of signaling with electricity, including clocks, are quite numerous. There have been about ten thousand patents granted in the electrical art already, and the outlook for electrical invention seems very bright still —brighter than ever before.

The question of modifications (which was discussed at the last meeting of this society) is easier of solution than some others. A man of course cannot wait until he invents all the modifications or species under his genus, if he did some one else might get a patent while he was doing so. If you secure a good broad generic claim and are the first one to occupy the field why will not this answer all practical purposes as near as possible? If any one else invents a modification of your apparatus it is, of course, tributary and subsidiary to your patent. His modification is covered by your patent. Now, of course, it would be well for a man to suggest all the modifications possible, but there is sometimes no limit to modifications. An inventor ought undoubtedly to take out subsequent patents on all the good and substantial modifications he afterwards invents so as to fully occupy the field, even if these other inventions be tributary to his invention, as this is sometimes a question of doubt, though not often, and sometimes you can be very much annoyed by patented modifications

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in adverse hands. It is often doubtful whether one thing *is* a modification of another, and very often you are called on by the patent office to divide out subject-matter which *you* think is a modification. Of course, if the latter operates on a different principle from the other subject-matter, and a generic claim cannot be secured which covers both or all, then they are not modifications of one another, but are separate and independent inventions. It is not an easy matter to determine these questions sometimes.

What can be included in one application is also difficult to say. If several things have a special community of operation, that is, if one is specially adapted to be used with another, and cannot be used generally with other devices, then they can be joined in one application. In these latter cases also, the patent office often calls for a division.

It seems best, in order to cover modifications as much as possible, to put in your specification something like the following: That you do not limit yourself to the apparatus shown, as the apparatus may be varied and made in various forms without departing from the spirit and scope of your invention, and that you reserve the right to make such changes in practice as fall within these limits.

The advisability of taking an appeal is sometimes under consideration. Examiners are, as a rule, quite fair, except in some instances. Each has his peculiarities. It is of the greatest importance to understand your examiner in prosecuting a case. What will be allowed by one will not be allowed by another. It amounts to a study of men as well as a study of practice and your case. An appeal is scarcely warranted unless you have a *bona fide* grievance and are being seriously wronged. It might have been adverted to in the previous remarks, that there does not seem to be enough intercourse and exchange of references between the different divisions of the office. Each division regards itself somewhat in the light of an independent sovereignty exercising an independent and exclusive jurisdiction, and claims are sometimes allowed by one division which could readily be anticipated in another.

Among the needs of the patent office might have been mentioned the want of some means by which to investigate the question of public use. This office has no means whatever of getting at this question, except in interfering cases. This is an extremely perplexing question to handle, nevertheless it would seem that this office should have some means whereby this matter can be looked into. The patent office is often censured for granting patents for old things—things that have been long in public use—yet if these things are not among the records in the patent office, and are not within the knowledge of an employé, there is no other course to be pursued—a patent must be granted. An application for a patent under the law and practice is an *ex parte* proceeding, and no notice is taken of affidavits filed in opposition to the grant. The American system might with advantage adopt something like the English system, wherein any interested party is allowed to oppose the grant of a patent upon good and sufficient grounds, all applications for patents being duly advertised beforehand.

It is of the utmost importance to have your inventions illustrated by first-class drawings, which show clearly every feature and modification of your invention. This is rendered imperative for the reason that examinations by the office of the antecedent state of the art are made from the drawings almost entirely. Specifications are rarely consulted, except when there is doubt about what the drawings show. So that where you get a patent and do not show clearly and unmistakably every feature, some subsequent party may possibly get a patent for what you have so described. Of course you are aware that every modification described, unless it be an obvious one, must be illustrated in the drawings. So that it does not do to suggest a modification unless you illustrate it.

Before closing, I cannot refrain from paying a high tribute to the examiners of the patent office. I would not have you think, from any of the above remarks, that I am unfriendly to them or have had cause to say aught against them, for my relations with them, both in the office and out of it, have always been of the most friendly and cordial nature. I have often expressed the views contained herein while a member of the corps. Their lot is not altogether a happy one. You have no idea, I am sure, of the amount of bad grammar they are inflicted with, and the quantity of bad spelling, and the ignorance they have to contend with. The idea has been suggested that specifications should be printed as they are written, without official corrections, so as to show the public just how skilled some inventors and their attorneys are. The idea is not a bad one. You would scarcely recognize some specifications before and after they have received an official dressing.

You know, of course, that the patent office acts only on what is put before it. It does not suggest claims and the like, or supply defects, except when they are matters of form, and rarely then. Examiners are therefore very often blamed for the ignorance and mistakes of others. The patent office undoubtedly ought to have some requirements for admission to practice before it. The requirement of the rules of practice that any person of ordinary intelligence can practice before this office is absurd. Every one comes within the limit of this restriction. If some good regulations were adopted in this line, the office would not be two or three months behind in its work, as it is to-day, for much extra labor is thrown upon the office by the very ordinary intelligence of many of those practicing before it.

I thank you for your kind attention, and close, hoping I have not wearied you, and offering you an apology for the hurried manner in which this paper has been prepared.

EUROPEAN SUBTERRANEAN WIRES.

In London all the telephone wires are overhead, but the telegraph wires are mostly underground, the cables being made in lengths of 400 yards and drawn through iron pipes. English experience in underground cables has been by no means favorable.

Thirty years ago underground lines were laid, at great cost, connecting London, Manchester, Liverpool, and other places, the whole of which became defective in a few years and had to be abandoned.

In 1873 an underground cable was laid between Liverpool and Manchester, 36 miles, 14 miles in iron pipes, with lead joints, at a depth of one foot; and 22 miles in earthenware pipes in three feet lengths, with Stourbridge clay joints, at a depth of two feet. The wires were insulated with two coatings of gutta-percha and intermediate coatings of Chatterton's compound, and the cable was made up into lengths of 400 yards. The utmost care was exercised in laying the cable and making the joints; but, notwithstanding, it did not prove a success.

In Germany there are about 15,000 miles of underground wires, and in France over 7,000 miles. In the former country, cables similar in construction to submarine cables are used. The first of these was laid down between Halle and Berlin (a distance of 106 miles) in 1876.—*The Telegraphist* (London).

STREET OWNERSHIP.

Street car companies only own the surface of such streets as they choose to occupy. Below the surface the gas and water works companies are sole proprietors. Above, the wire concerns—such as telegraph, telephone and electric companies—are supreme. Any other odd space, that may happen to be about, is used by the city for storing dirt.—*New Orleans Picayune.*

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CORRESPONDENCE.

NEW YORK AND VICINITY.

Demolishing Downtown Buildings.—The Proposed Telephone Building.—An Injunction Against the Steam Company.—The Labor Troubles in New York.—Electric Railway Investigators.—Shabby Condition of Electric Light Lines.—The Pennock Underground Company.

THE most prominent down-town industry at present appears to be the demolition of buildings. The property of the Equitable Life Assurance Society, on the block between Pine and Cedar, is perhaps the most active field of destruction. The twelve months between two May moving days is barely sufficient time for constructing the modern office buildings, and consequently the work is pushed forward with all possible speed. In this particular case the arc lighting system is quite extensively used, to permit of night work, and the 1st of June will bring the preparatory operations nearly to a close. On Cortlandt street the old buildings are also being removed, the site of which is to be occupied by the new telephone building. It appears to be a very general impression that this location will next year be quite generally selected by the managers of the various firms and corporations who are more or less identified with the electrical industry.

The pipes of the New York Steam Heating Company have very properly been considered a formidable evil to other existing and proposed subterranean systems, of which the electrical is destined to be one of the most important.

The Commercial Cable Company, in order to prevent future annoyance to its underground cables, has secured an injunction against the steam company, restraining it from laying pipes through Nassau street, between Wall and Fulton. Complaints are also made that the water in the city pipes is unduly heated by the adjacent steam pipes. As this service is by no means a public necessity, it appears to be a hardship that other subterranean occupants should suffer as they already have done, and are likely to do in the future. This injunction is apparently a step in the right direction, and should be taken as a precedent in the dealing with all proposed extensions of the steam heating service.

Until the recent strike at the Edison machine works the extended labor troubles of the country had not directly affected electrical interests. Several of the manufacturing establishments have amicably settled any differences of opinion which had arisen between the proprietors and employés; among these were J. H. Bunnell & Co., Pearce & Jones, Bergmann & Co., and the Western Electric Co., or, more properly, perhaps, Haskins & Stiner, the contractors in the factory of the latter company.

The organization of the New York Electrical Club has attracted considerable attention, and it was apparently the revival of an idea which has long existed that some association of that character was needed in this city for the especial promotion of good fellowship. There is ample material existing in New York if efforts were concentrated toward a common object. There are, however, so many conflicting ideas as to what constitutes a proper basis of unity, that individual resources are scattered among several minor societies without accomplishing the desired result of a thoroughly useful and permanent organization upon a strong financial basis.

Quite an extensive delegation from Boston has visited this city for the purpose of learning what progress has been made in electric railway development. The Daft establishment, at Greenville, N. J., was inspected on Thursday, and the following day the Sprague motor on the 34th street branch of the elevated railroad was examined. Among the visiting statesmen who would be able to distinguish the difference between an electric motor and a coffee-mill, were Messrs. P. A. Dowd and A. F. Upton. The latter gentleman, especially, is an earnest advocate of electrical power transmission, and his opinion will doubtless be of considerable weight in determining what is to be done in this line in eastern Massachusetts.

The dilapidated appearance of the arc lighting lines in the down streets, especially, is attracting considerable criticism from those who are competent judges of that class of work. It is hardly probable that any improvement in their condition is to be expected pending the decision of the Commission on Electrical Subways.

A new press association has been incorporated. They intend furnishing the most reliable news from all parts of the United States and Europe. Col. Robert G. Ingersoll is counsel for the association. Mr. A. B. Chandler will represent the Postal Telegraph Company and Mr. Mackay's interest. Mr. F. W. Jones, general manager of the United Lines, is also general manager of the press bureau.

The Pennock Underground Telegraph Company has secured privileges in Jersey City for laying its conduits. Its managers appear to be quite active in their preparations for the future, and hope eventually to build up an extensive system.

NEW YORK, May 21, 1886.

PHILADELPHIA.

A General Ordinance for Underground Work.—The Latest Printing Telegraph Scheme.—The Postal makes a Business Arrangement with the American District.—The Ridge Avenue Electric Railway.—Decision Against the Bucket Shops.—The Baltimore and Ohio Secures Telephone Privileges.

THE special committee of councils, appointed to draft a general ordinance regulating the laying and construction of underground wires, conduits, cables or tubes, in the city of Philadelphia, who have had the matter under consideration for several weeks past, have finally completed their labors. The ordinance directs that all companies applying for privileges to lay or construct wires, conduits, cables or tubes, to file with the Board of Highway Supervisors an application in writing, accompanied by plans and specifications, setting forth the route or routes upon which they desire to lay or construct the same.

In order to avoid encroaching on routes already occupied, and to avoid interfering with the gas, water and sewerage system, the Board of Highway Supervisors are given authority to alter and change the route or plans submitted as they may think best for the interest of the city. The Board of Highway Supervisors are also authorized to issue a permit to any company to which privilege has been granted for the construction of main lines, to lay or build branch lines, provided the said branch lines shall not extend beyond five squares from the main line. The laying and construction of any line of wire, conduits, cables or tubes, shall be done under the supervision of the chief of the electrical department, and subject to his approval.

The following annual license charges are to be made. They seem rather steep to me; but our patriotic councilmen are reckless as to how they "rub it in" where their own pockets are not concerned: $20 per running mile on all conduits, tubes or pipes for electrical conductors, not exceeding 2½ inches in diameter; and on those not exceeding 6 inches, $40 per mile or part of a mile; and on those not exceeding 12 inches, $80 per mile or part of a mile; and on all other conduits, tubes or pipes for like purposes, not exceeding 15 inches, an annual license charge of $125 per running mile or part of a mile; and an annual license charge of $2 per mile, or part thereof, shall be made on all electric light wire or wires in use; and $1 per mile, or part thereof, shall be made on all telegraph or telephone wire or wires in use which are laid underground, whether singly or in conduits, cables, tubes or pipes.

Here's the regulation new scheme to do away with all previous methods of telegraphy. It crops out about once per annum. Within a few weeks another wonderful printing telegraph enterprise has been launched, being apparently an offshoot of the Hathaway instrument, which has figured quite prominently in the newspaper columns during the past year. At a recent public exhibition at 327 Walnut street, the usual number of eminent capitalists and prominent business men watched the manipulation of two of the new instruments placed side by side. The impression upon the reporter present was as follows:

> A wire led from one to the city of Reading, sixty miles away, and, returning, ended at the other, a few feet off. A lad stepped up to the invention, pressed the lettered keys just the same as in operating a type-writer, the electric current flashed instantaneously 120 miles and printed in plain, bold letters on a sheet of paper upon the adjoining machine a message. The same letters were recorded upon an endless roll in front of the sender as were printed upon the receiver, so that a mistake made could readily be corrected. The apparatus is the invention of Mr. J. H. Linville, for a number of years president of the Keystone Bridge Co., and it is believed that it will prove a decided rival to the telephone on account of its simplicity and the fact that one who can read can operate it. Messages can be sent or received upon the same instrument by merely turning a switch. Unlike a telephone, if the receiver happens to be absent when "called up," the message is not lost, but it automatically records itself, even though it should be 1,000 words in length. It is impossible to read by sound or tap the wires over which a message from this invention is sent. At the Associated Press office the operators receive all the messages upon type-writers. They find it beats handwriting both for speed and legibility. With one of Mr. Linville's machines the type-writer would be dispensed with and much time saved. The apparatus is the property of the International Printing Telegraph Company, which proposes to establish a central office or exchange, and have subscribers after the manner of the telephone companies.

The American District Telegraph and the Postal Cable Company have formed a contract, by the terms of which all messages left at the American District offices for transmission to other cities will be sent over the wires of the Postal company, and all postal messages received in this city will be delivered by the American District messengers.

The new arrangement is for a long term of years. The officers of the Postal company claim that they cover nine-tenths of the profitable telegraph territory in the country, its lines extending as far west as Lincoln, Nebraska, while lines are being stretched to the Pacific coast. Some time ago the American District company left the Western Union and joined hands with the Baltimore and Ohio company for local business, but believing that their services to the public could be increased, they effected the new arrangements with the Postal company. It is said that the Western Union company has recently been negotiating to enter into a contract with the American District, but the latter declined to consider their proposition.

During the past week cars have been run on Ridge avenue, between the depot at 29th street and Laurel Hill cemetery (about

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one mile and a half), by means of a new electric motor. Each afternoon a car filled with passengers has been run, and the electrician in charge does not hesitate to express the opinion that with heavier machinery, cars can be propelled over the entire route. The conduit has been laid only the distance mentioned. It is only four and one-half inches wide by nine inches deep, and is laid on concrete, covered with a layer of Portland cement. Sewer connections at intervals permit the washing out of the slot and also carry off the rain water. In the conduit on each side of the slot is a copper conductor, one-fourth of an inch wide by one inch deep, on the bottom of which runs a grooved piece of cast iron. Running in the slot, supported by two wheels, is what is called a traveler. This is provided with two springs, which run along the cast iron on either side, receiving the electric current. The traveler is fastened to the car by small chains, and from its centre are wires extending up into the car, which connect the motor carried on the car with the two currents. Of the two conductors in the conduit, one carries the current from the generator to the motor, the other from the motor to the generator. An engine at the depot will furnish the necessary power. The estimated cost per day of running the electric car is $1.84, while the cost per day of operating a horse car is $4.74. Both estimates are exclusive of salaries. It is calculated that an electric railway 10 miles long, and having 50 cars, would cost $147,400.

Charles E. Morgan, the master in the suits of the "bucket shop" proprietors to have the Philadelphia Local Telegraph Company restrained from moving stock-tickers from their offices, has filed a report adverse to the plaintiffs. He holds that the business conducted by them is an illegal one, and that while the telegraph company is a common carrier, it is not bound to collect and furnish information as to the value of stocks to every person who applies.

The Supreme Court recently sustained the decision of Judge Arnold, of Court of Common Pleas, No. 4, by which he decided that the Bell Telephone company was to the public, like a railroad, a common carrier. The Baltimore and Ohio Telegraph Company had asked the Bell Telephone company to place a telephone in its office, but the latter refused, on the ground that they had a contract with the Western Union company. The decision of the court will compel the introduction of the instrument.

PHILADELPHIA, May 18, 1886.

BOSTON.

Business of the New England Telephone Company for 1885.—The Field for a Practical Village Exchange.—The Last of the Lowell Syndicate.—Gas Companies Anxious to Engage in Electric Lighting.—The Edison Company at the "Hub."

THE report of the directors to the stockholders of the New England Telephone and Telegraph Company for the year ending December 31, 1885, is a very interesting document.

As shown by the treasurer's statement, the gross earnings for the year were	$920,841.38
Expenses	697,024.62
Net earnings	223,816.76
Compared with the year 1884, there was an increase of gross earnings of	$12,592.31
And an increase of net earnings of	8,862.38

The construction and reconstruction for the year has been as follows:

In the Boston exchange, 25,837 feet of aerial cable, 4,696 feet of underground cable, and 1,530 feet of submarine cable have been placed, and 32 poles set. In the suburban territory, about Boston, 10,175 feet of cable, 280 poles, and 24 miles of wire.

The Springfield exchange has been practically rebuilt, and 9,475 feet of cable hung.

It is interesting to observe the amount of cable that has been put up, indicating the advance of ideas, and the desire of the company to do away with the overhead wire business.

New extra territorial and toll lines have been built quite extensively, and in a few years New England will be covered with a net-work of inter-connecting telephone wires.

In the process of the entire work upon exchanges and public lines, there has been used:

Of 100 wire aerial cable	16,090 feet.
" 50 " " "	37,925 "
" 25 and 20 " "	4,592 "
" submarine cable	1,880 "
" 100 wire underground cable	4,696 "
Making a total of	65,083 feet.

The full report should be read to understand and comprehend what an intelligent and business management can do with a difficult problem.

The Gilliland village system was put in Leicester, Mass., in September last. Four circuits are employed, carrying 13 subscribers' stations. This, or some other system of connection for small places having but few subscribers, is a great necessity, as the report says "we are still operating a number of small exchanges at a loss. Some of these should be closed, unless we can secure a sufficient number of subscribers to render them at least self-supporting." There seems to be inventive talent enough engaged on some lines of telephonic discovery. Every inventor seems to consider the crying want to be a variant of the telephone transmitter and receiver, sufficiently unlike the patents owned by the Bell company, to pass muster before such critical critics as the common councilmen of Indianapolis, who recently decided that the Wallace instrument did not *look* like the Bell and Blake, consequently it was no infringement. When the craze for producing a pair of telephones for some restless syndicate of promoters passes by, we may hope to see a crop of inventions bearing on such points as indicated. All over the country the same trouble exists; the local companies have been obliged to take out telephones in localities where it does not pay to keep an operator. One trouble with the Gilliland system is the multiplication of lines which have to be called.

The time is surely coming when the use of the telephone will be extended into places where now it cannot go, because of the expense of the present forms of telephones and of operating the same. It is a well-known fact that there are not as many telephones in small places, at the present time, as there were four years ago. I saw an article from the New York *Tribune* recently, in which was stated that one reason why Mr. Theo. N. Vail severed his connection with the Bell company, as general manager, was that his policy was to put the rentals for telephones lower, and make more money on the increased number put out at a low rate, on the principle of large rentals at small rates. Whether this was so or not, the fact remains, that there is an immense field for the telephone not now utilized or catered to, and which would yield an immense income if properly reached. Among the apparatus needed is a cheap and economical system of intercommunication, without the assistance of a paid operator. Over 100 inventors have tried to cover this point, in part, by the use of individual bells, but so far they have not been successful; stock schemes without number have been exploited, but the hard result has not been attained.

In my last letter I noted that the legislative committees reported adversely on telephone and underground matters. Since then, substitute bills have been brought forward, the underground matter was again fixed, but the matter of the Bell company holding stock in other corporations in this or any other state, and of the taxation of telephone companies, are still under consideration.

Mr. Glidden, the last remnant of the notorious Lowell syndicate, was left off from the directory of the New England Telephone and Telegraph Company this year. Mr. Glidden may possibly shine in other than telephonic firmaments.

On the 7th inst., Colonel John H. George, of Concord, N. H., W. D. Cadwell, of Nashua, N. H., and Charles H. Allen, of Boston, gave a hearing at the Revere House as arbitrators of the disagreement between the Erie Telephone and Telegraph Company, of New York, and William A. Ingham, Loren N. Downs, William H. Bent and others, members of what is known as the Lowell syndicate. The three gentlemen last named asked for compensation for services rendered as directors and officers of the Erie company. The counter claims of the company amount to $127,-000, and are made up of alleged losses to the company in the purchase of telephone lines, exchanges, inferior material, construction of lines and various other items made by the defendants. The members of the syndicate have as counsel G. F. & D. S. Richardson, of Lowell, and M. F. Dickinson, Jr., of Boston. The counsel for the Erie company are General Butler, J. N. Marshall and William H. Anderson.

In the course of Mr. Bent's testimony there were some sharp colloquies between him and General Butler. Mr. Bent said:

"I do not know that the syndicate paid a single dollar to the Cleveland company. I never paid a dollar myself. I made $50,-000 on the transaction, and it went into my pocket. I never put a dollar from my own pocket into the Southwestern company. I put $12,500 in cash into the Northwestern company."

General Butler—"Now, sir, did the syndicate ever give any money for any other purpose?"

Mr. Bent—"We contributed toward the election of General Butler for governor."

General Butler—"That is the only good thing I ever heard of your doing. I am glad to know it."

Mr. Bent—"It was the most foolish thing I ever did."

Continuing, witness said that he thought he gave a check when he contributed to General Butler's election, and that he handed it to Mr. Webster, General Butler's partner, in the Lowell depot; he had made other contributions to Lowell institutions, but did not remember in what amounts; the contributions were made both individually and for the syndicate. "I don't know," continued the witness, "that the Erie company paid $7,000 more for the Eastern Dakota company than was received by that company, but I suppose that was so; $77,000 in all was paid by the Erie, and I understand that $70,000 was paid to the seller."

A recess was then taken. The rest of the day's hearing was devoted to ascertaining to what extent witness is interested in other companies. Arguments on law points will be made during the coming week, and the hearing will be continued in the following week.

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Way down in Maine the governor and council have assessed taxes against the telephone companies as follows: New England Telephone and Telegraph Company, $1,875; Beedy & Linscott, $1,125. Telegraph companies—Maine Telegraph Company, $1,250; Western Union, $2,500; Great Northwestern, $125; Eastern, $500; International, $1,250; American Union, $175; Atlantic & Pacific, $175.

There is a quiet movement on the part of the gas companies in this state, to secure changes in their charters allowing them to furnish electric lights, in addition to those mentioned in my last, in the legislature. Under suspension of the rules, Mr. Gove, of Suffolk, presented the petition of the Chelsea Gas Light Company for authority to furnish electric lights in the city of Chelsea and town of Revere. Referred to the Committee on Manufactures.

The senate then concurred with the House in the suspension of the rules to allow the presentation of the petition of the Charlestown Gas Light Company to furnish electric lights.

The case of C. Snow, of Harwich, *vs.* the Hon. J. B. Alley, of Lynn, is to be retried at the October term of the Supreme Court, at Barnstable. The case has been heard here three times, and on each occasion the jury failed to agree.

Our suburban friends indulge in a kick at poles on the highways whenever a good chance offers. Such an opportunity offered recently in Somerville, the residents of some of its beautiful streets protesting vigorously against telephone poles.

The Edison people are trying to persuade the Boston authorities to allow them to put down their underground system from Indiana place to Court street, on Washington street; this looks like permanent business for the incandescent lamp.

The New England Telephone and Telegraph Company paid their dividend on the 15th inst., at the rate of 75 cents per share. There is talk of the next dividend being at the rate of 4 per cent.

BOSTON, May 16, 1886.

CHICAGO.

The Story of a $3 per Month Exchange.—Importance of Proper Line Construction.—Fire Caused by Patent Joints.—Electric Storms and Tornadoes.

THERE is in a certain southwestern town an electrical tangle which is curious for the turns and twistings of the track it has taken. The rumpus is between the authorities and a certain telephone company. It is not the Central Union, and has nothing whatever to do with the Indiana muddle.

Some years ago there was a telephone company organized in the town referred to, and the charter under which it operated had a clause containing a scale of rates which reduced the rentals in such proportion as that when one hundred subscribers were obtained the rentals should be made $3.00 per month.

This charter was accepted before experience had shown that an increase in the number of subscribers means an increase in the number of conversations per day, and a consequent increase in the expense of running the exchange, with a resulting increase in value to each subscriber, and that all this increase is in a sort of mathematical proportion. This by way of parenthesis. To return:

The original company did not rope in one hundred subscribers; they sold out their exchange, but not their charter. The new company sailed in and did make an exchange of over one hundred subscribers.

If this was a romance, right here would be a heading like this: "Chapter two. A collision."

Among the provisions made between the telephone company, which did not purchase the charter containing the $3.00 contingent clause, and the fire-worshipers of this town of X., there was recorded a provision something to this effect: In the house of the chief of the army of fire-worshipers, and also in the business office of the same person, there shall be placed telephones with connections at the central office, so that in case of an alarm of fire the chief may at once be notified; but under no circumstances shall these or either of them be used for any other purpose whatever.

Now it occurred one day that the honorable, the mayor of X., required to converse with the chief aforesaid, and demanded to be placed in connection with him through "Hullo, Central"—Hullo presumably being the front name of the individual in charge at the central office. Yet Hullo, having orders otherwise, refused to accede to the request of Hizzoner. The case was respectfully referred.

The chief operator declined to entertain the proposition, and the case was again respectfully referred. The manager would not consent to the innovation, and the case was again referred.

The superintendent, or some higher great mogul, positively refused to break the rule, even for his Hizzoner, who waxed wrothy and painted the atmosphere—not red, which is the typical color of a typical fire-worshiper—but a wicked cerulean hue, and quoted from Holy Writ, "Vengeance is mine," etc., and proceeded straightway to demand of the officers of the telephone company, which did not purchase the charter containing the three-dollar contingent clause, that they at once reduce their rates of rental to $3.00 per month or take the consequences.

The company indignantly refused. Hizzoner threatened to repeal the charter. The company said, "Do it."

And Hizzoner, with the aid of the governing body of the corporation, did repeal the law, and laughed in glee when he thought "now have they no charter."

And the company also laughed, for Hizzoner at once discovered that he had been too hasty—that he now had no law which would control the charges of any telephone company.

And the company also laughs, because the only charter besides its own is now dead and buried, and it is now boldly charging four dollars per month, giving its subscribers good service, and collecting its payments with fearful regularity.

In the commencement of the telephone enterprise, and again in electric lighting, there was everywhere a perfect and utter disregard for future permanency in the matter of construction. Wires and insulators were attached here, there, anywhere, so that a fastening of some nature was obtained, and to "get there" before the other fellow, at as small an outlay of money as possible was the end and aim of all construction.

In my mind there is an illustration of the different results which a different method of treatment may bring about.

Talking with a telephone man on this subject recently, he illustrated the position he had taken, that good work means good pay, in telephoning as well as in other branches of business, by citing some lines which he is conversant with.

"Here," said he, "is a line 67 miles long. This is put here to stay. Much of it is along a river, and of course it had to be well built. It has a No. 8 iron wire, and 40 poles to the mile. This line was constructed in 1883, and has lost just two half days in that entire time. The certainty that it will do its work when called upon makes it reliable as an earning institution, and receipts show what a well built line can do.

"Here is another. This line is 83 miles in length. This, too, has a No. 8 iron wire, and 40 poles. In January last an extension was constructed of No. 10 B. and S. copper, with 25 poles to the mile. This line never fails, and the receipts are wonderfully certain. The earnings are abundantly satisfactory, as you see, but of course they are not for publication. The point I am making is that the expense of more complete construction is always well returned with interest, through the positive reliability of the line and the consequent confidence of the public, and *vice versa*, when the work is less completely put up, its unreliability will certainly very materially reduce the income."

And this is equally true of an electric light line, either within doors or outside. Permanency should enter into the calculation. Take the matter of joints in a wire, for instance. How many constructors of electric light lines are aware, or if aware, are heedful of the danger of fire from a loose "connector"—that abominable, double-ended brass substitute for a solid and soldered wire joint?

I have heard electric light people extol these dangerous inventions of the enemy, because they were so neat, so handy, and so perfect as connectors. There has sometimes been an epidemic of these in a town not far from Chicago, for I know of one week of good, solid work on a central plant there, where the wire is about three miles long, taking out this sort of joint and replacing the connection with a good, old-fashioned line joint, such as all the old style telegraph men know how to make.

Then, too, "they are screwed up so tight that the heads are twisted off, and it is impossible for the screw to work loose."

Yet, this assumption to the contrary notwithstanding, in this merry month of May, 1886, this much is recorded for the benefit of this and similarly instructed constructors.

A fire alarm, May 8th, from Box No. —, was caused by the electric light wires running through the establishment at the corner of the alley, between M. and W. streets. Said fire was caused by an electric arc in a brass connector, which was the result of a loose-binding screw. Damage nominal. For further particulars inclose address and a two cent stamp.

Nature's electrical exhibitions, this season, are both plentiful and extremely brilliant. The storms of the week, from the 9th to the 15th of May, have covered a wide-spread area, and sown death and destruction in their path. Of all the list there is none which in this sad particular can rank Kansas City, and the mortality there is all the more heart-rending from the fact that the victims were children for the most part—little ones in the lower and middle grades of the public school; and in two of the other buildings demolished, the victims were girls. Few, very few men were sacrificed, but the weaker sex and those of tender years were the principal sufferers.

The school building which succumbed to the hurricane—it was neither a cyclone nor a tornado—had been condemned by an officer in the educational department, and for his pains he had been thrown out of his office, and the building had been patched up so as to seem good. The result of this superior wisdom, so far, has been the death of thirteen little ones, a roll which will undoubtedly be swollen from the ranks of more than as many more who sustained severe or trifling injuries in the sad disaster.

The destructive storms of the past five days have all been quite similar in character, and their stamping grounds include much of Illinois and Ohio, part of Missouri, Kansas, Iowa and Virginia. It has been a pretty good week for storms.

CHICAGO, May 15, 1886.

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ELECTRICAL NEWS AND NOTES.

AFFIDAVIT OF ZENAS F. WILBER.

The following affidavit is a recent sensational devlepoment in the Pan-Electric investigation. The charge of bribery has been explicitly denied by a counter affidavit from Professor Bell, but neither of the documents have been admitted in evidence.

City of Washington, District of Columbia ss.:

Zenas Fisk Wilber, being duly sworn, deposes and says: I am the same Zenas Fisk Wilber who was the principal examiner in the United States Patent Office, in charge of a division embracing all applications for patents relating to electrical inventions, during the years 1875, 1876, and till May 1, 1877, about which latter date I was promoted to be examiner of interferences; that as such examiner the application of Alexander Graham Bell, upon which was granted to him letters patent of the United States No. 174,465, dated March 7, 1876, for "Multiple Telegraphy," was referred to me, and was by me personally examined and passed to issue. And I am the same Zenas Fisk Wilber who has given affidavits in the telephone controversy, commonly called the "Bell controversy," in which a bill has been filed and suit brought in the Southern District of Ohio, by the United States, for the voidance of letters patent No. 174,465, issued March 7, 1876, and No. 186,787, issued Jan. 30, 1877, both to Alexander Graham Bell, which affidavits, so given by me, were used at the hearing before the commission in the interior department, consisting of secretary Lamar, assistant secretaries Muldrow and Jenks, and commissioner of patents Montgomery, which commission sat for the purpose of advising the department of justice as to the advisability and propriety of the general government bringing the suit *supra*. In none of such affidavits heretofore made by me, and referred to in this affidavit, have the exact facts and the entire truth been told by me in relation to the circumstances connected with the issuance of the said patent No. 174,465. These affidavits were made by me under circumstances which I propose to relate herein, and obtained from me to serve the ends and purposes of the parties who influenced me.

In order that parties may be vindicated and injustice rectified, I have concluded to tell the whole truth and nothing but the truth. It will be impossible for the courts of the country to mete out exact justice without a knowledge of the influences brought to bear upon me while examiner in the patent office in 1875, 1876, and 1877, which caused me to show Prof. Bell, Elisha Gray's caveat, then under my charge and control as by law provided, and which caused me to favor Bell in various ways in acting on several applications for patents by him made. This conclusion has not come upon me suddenly, but after due and deliberate consideration and after having carefully weighed the consequences which must result from this disclosure. I am fully aware that it may place me in an awkward position with some of my friends, and, possibly, before the public, that it may even, alienate some of my friends from me. Nevertheless, I have concluded to do as above stated regardless of consequences without the hope or promise of reward or favor on the one hand, and without fear of results on the other hand.

The affidavits hereinbefore referred to were executed July 30 and Aug. 3, 1885 (these being duplicates), Oct. 10, 1885, Nov. 7, 1885, and Oct. 21, 1885. One of these affidavits, viz., the one of Oct. 21, 1885, given at request of the Bell company by Mr. Swan, of its counsel, was given when I was afflicted with and suffering from alcoholism, and was obtained from me when I was so suffering, and, after it had been so obtained from me I was villified and attacked before the commission referred to. Under such conditions my faculties were not in their normal condition, and I was, in effect, duped to sign it—not fully realizing then, as I do now, the statements therein contained. I had been drinking and was mentally depressed, nervous, and not in a fit condition for so important a matter. As stated, I did not realize (I could not in my then condition) the effect or scope of the affidavit, the data for which were supplied by Mr. Swan, who paid me $100 therefor, for the Bell company. In this instance and at this time I am entirely and absolutely free from any alcoholic taint whatever; I am perfectly sober and a conscious master of myself, mentally and physically. This affidavit is, consequently, the outcome of a changed mode of life and a desire on my part to aid in righting a great wrong done to an innocent man. I am convinced that by my action while examiner of patents Elisha Gray was deprived of proper opportunity to establish his right to the invention of the telephone, and I now propose to tell how it was done.

The attorneys for Prof. Bell in the matter of the application, which became patent No. 174,465, were Messrs. Pollok and Bailey, then a leading firm of patent practitioners in Washington city (since dissolved, and each in business for himself). Major Bailey of that firm had the active management of the case, and several times appeared before me during its pendency in relation thereto. Major Bailey and I had then been acquainted for almost 18 years; we had for a time been officers in the same regiment and staff officers upon the staff of the same brigade commander. Upon my appointment to the patent office in 1870 our old acquaintance was renewed, and for years we were exceedingly friendly, and still are so, even to this day. I was poor when I became examiner, and consequently was in constant and great straits for the lack of ready money; in such straits I had several times borrowed money from Major Bailey, notwithstanding the fact that Commissioner Leggett had in 1871 or 1872 issued an order prohibiting employés of the patent office from borrowing in any way or under any subterfuge from attorneys practicing before the office or from inventors, which order was then and is still in force. I was, consequently, in debt to Major Bailey at the time the application of Bell was filed in the office; in addition I was under obligations to him for a present to my wife—a very handsome and expensive gold hunting-case lady's watch, which I understood he procured from George P. Reed & Co., of Boston, Mass. I consequently felt under many and lasting obligations to him, and necessarily felt like requiting him, in some degree at least, by favoring him in his practice whenever and however I could. As I recollect, I borrowed $100 from him about the time the Bell application was filed. He was known as a liberal man, and gave expensive presents, and loaned money to others in the office. Feeling thus in his power from the obligations noted, surrounded by such environments, I was called upon to act officially upon the applications of Alexander Graham Bell.

When I suspended Bell's application, because of the Gray caveat, I did not, in the official letter to Bell, give the name of the caveator nor his date of filing. Major Bailey appearing before me in regard to such suspension I allowed him to become acquainted with both facts, telling him personally the same, so that he immediately knew the exact facts upon which to base the protest he subsequently filed against such suspension and which was referred by me to the commissioner in person for instructions. The commissioner directed me to investigate and determine if possible which (the application of Bell or the caveat of Gray) was filed the earlier on Feb. 14, 1876, and to be governed by such finding of fact as to the maintenance or dissolution of such suspension. From the circumstances hereinbefore detailed I was anxious to please Major Bailey—keep on the best and most friendly of terms with him, and hence was desirous of finding that the Bell application was the earlier filed, and I did not make as thorough an examination as I should have done in justice to all concerned. So, when I found in the "cash blotter" the entry of the receipt of Bell's fee ahead of the entry of the receipt of Gray's fee I closed the examination and determined that Bell was the earlier, whereas I should have called for proofs from both Bell and Gray and have investigated in other directions, instead of being controlled by the entries alluded to and the statements of Major Bailey to me. The effect of this was to throw Gray out of court without his having had an opportunity to be heard or of having his rights protected, and the issuance of the patent hurriedly and in advance of its turn to Bell. Immediately thereafter I again borrowed some money from Major Bailey, which has never been repaid; we have never had a settlement, and for years I was constantly in debt to him and still am. He has as yet demanded no settlement or repayment from me.

After the suspension of Bell's application had been revoked, Prof. Bell called upon me, in person, at the office, and I showed him the original drawing of Gray's caveat, and fully explained Gray's method of transmitting and receiving. Prof. Bell was with me quite a time on this occasion—probably upward of an hour—when I showed him the drawing and explained Gray's methods to him. This visit was either the next day or the second day after the revocation of the suspension. There were several clerks and assistants in the room at the time, who might have heard the conversation, when I showed Prof. Bell the drawing and verbally explained to him the methods of Prof. Gray. Bell had been in the office before this, on several occasions, in relation to other cases, so we were then acquainted; on this visit he was alone, and the visit occurred in the forenoon. About 2 P. M. of the same day he (Bell) returned to the office for a short time. On his leaving I accompanied him into the hall and around the corner into a cross hall leading into the courtyard, where Prof. Bell presented me with a one hundred dollar bill. I am fully aware that this statement will be denied by Prof. Bell, and that probably the statements I have made as to my relations with Major Bailey and his influence will be denied, but, nevertheless, they are true, and they are stated, subscribed, and sworn to by me while my mind is clear and my conscience active and bent on rectifying as far as possible any wrong I may have done. Gray's caveat was a secret, confidential document under the law, and I should not have been influenced to divulge the same; but I did so as hereinbefore related. Upon the following page I make a diagram of the room, (No. 118), the hall, and the cross hall where Prof. Bell handed me the one hundred dollar bill.

The assistants and clerks had free access to the archives and records in the room; they could go in and out, outside of regular office hours; the caveat was for some weeks in a file box on my desk and could have been taken therefrom and from the office, and kept over night without my knowledge, either by a messenger, a watchman, a clerk, or an assistant, or by a clerk or assist-

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ant from other divisions; at that time examiners' rooms were not locked and the key kept at the desk of the captain of the watch, when the rooms were not occupied, outside of office hours, as is now the case; nor were passes then required for employés to enter the building outside of regular office hours.

Prof. Bell, in his testimony in the Dowd case admits having had a conversation with me in relation to the caveat, but says as I remember it, that I declined to show him the caveat, which is not true. I did show him the original drawing as hereinbefore stated.

In corroboration of the fact stated herein that Major Bailey had an influence over me, I desire to refer to several other applications of Prof. Bell's which were acted on and became patents in remarkably quick order, as will be shown by the records of the patent office. The application for this patent, 174,465 was filed Feb. 14, 1876, became a patent (after the several actions thereon) March 7, 1876; for No. 161,739, filed March 6, patented April 6, 1876; for No. 181,553, filed Aug. 12, patented Aug. 29, 1876; for No. 186,187, filed Jan. 15, patented Jan. 30, 1877; for No. 178,399, filed April 6, suspended May 18, 1876, on account of a possible interference with another pending application of Prof. Gray, was amended, and protest against interference filed May 20, suspension revoked, case passed to issue May 29, and patented June 6, 1876. Such rapid progress from applications to patents are exceptional, and few such instances, if any, can be found outside of Bell's cases.

For the sake of justice, the easement of my own conscience, and to place myself right in this matter, I have concluded to tell the whole truth thereabouts, in so far as I had any connection therewith in an official capacity; and this without any regard to whom it may aid, help, or hurt; and I have thus concluded after full, frank consultation and conversation with my old college mate, comrade-in-arms, and long tried friend, Major Marion D. Van Horn; and I shall intrust this document to him, hoping and trusting that I may yet be able to repair in some degree the wrong done, and I stand ready, and shall always be ready and willing to verify this statement before any court or proper tribunal in the land.

ZENAS FISK WILBER

{ Seal of Notary. } Sworn to and subscribed to before me this 8th day of April, 1886. THOMAS W. SORAN, *Notary Public.*

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—SECOND ANNUAL MEETING.

The annual meeting of the American Institute of Electrical Engineers, for the election of officers and the transaction of other business, took place at the house of the American Society of Civil Engineers, 127 East 23d street, on Tuesday evening, May 18th. In compliance with the rules of the Institute, which prohibits the election of a president after two successive terms, Dr. Norvin Green, who has so ably filled that office since the organization of the society, was not a candidate for the presidency, but was elected a vice-president.

The list of officers chosen is as follows, the secretary and treasurer being re-elected:

President, Frank L. Pope; Vice-presidents, Dr. Norvin Green, Thomas D. Lockwood, Professor William A. Anthony, and George C. Maynard; Managers, Sidney F. Shelbourne, Capt. O. E. Michaelis, Prof. Cyrus F. Brackett, and C. O. Mailloux; Treasurer, Col. Rowland R. Hazard; Secretary, Ralph W. Pope.

The secretary, in his report, recommended that suitable action be taken to provide for more frequent meetings for discussion, in order to keep pace with the progress of the art, and thus render the Institute of still more substantial value to its members.

A communication from the secretary of the National Telephone Exchange Association was also submitted, inviting the co-operation of the Institute in securing the general adoption of the standard wire gauge.

Committees were appointed to consider both of these matters, and report to the general meeting on the following day.

The general meeting on Wednesday, May 19th, was devoted principally to the reading and discussion of the various papers prepared for the occasion. The first was upon the subject of "Underground Electrical Systems," by Sidney F. Shelbourne, which was attentively listened to, and gave evidence of careful research, and showed that its author had properly considered the numerous obstacles which are likely to be encountered in the prosecution of such effodient undertakings. The discussion which followed was of interest, developing as it did the fact that subterranean telephone wires are giving good service to a limited distance, while it had been found that lead sheathing must be properly protected from the ammoniacal drippings from the street, facetiously referred to by a distinguished member as stable products.

A paper devoted to the practical working of the mammoth tangent galvanometer at Cornell University, by Prof. W. A. Anthony (see page 217), was the subject of much favorable comment, this instrument being the largest of its kind in the world, and constructed especially for the measurement of large currents.

An intermission of one hour between the sessions was devoted to the wants of the inner man, a suitable combination of solid and liquid refreshments having been provided under the supervision of secretary John Bogart, of the American Society of Civil Engineers.

"Recent Advances in Telephony" (see page 218), by Thomas D. Lockwood, was the opening attraction of the afternoon session. It was interspersed with many oral explanations, and illustrated by diagrams upon the blackboard, which combined in lending additional attraction to a very interesting subject. It covered chiefly a branch of the telephone business with which most electricians are not thoroughly familiar, and demonstrated that contrary to the general opinion, every effort is being made to improve telephonic communication.

Mr. A. C. Fowler treated his hearers to a glimpse at the inside workings of the patent office, in his paper devoted to patent office practice. He confirmed a suspicion long entertained by many inventors, that examiners frequently consider it their duty to obstruct rather than facilitate the granting of patents, although admitting the necessity of thorough and intelligent investigation. The paper was entitled "The Patent Office and Patent Office Practice," and is printed in full in this issue. See page 227.

"Static Difficulties in the Multiple Telegraph" was exhaustively treated by F. W. Jones, who has devoted much attention to the subject. He has carefully studied the patents of all countries, and as a result of his researches presented a very complete history of the various devices which have been invented to overcome the obstacles presented by the static discharge in this branch of telegraphy. While the subject was not one of popular interest, the completeness of its presentation will make this paper of inestimable value to those who are called upon to investigate inventions in that particular field, and the time allotted to its preparation amidst a pressure of business overwhelming in itself, reflects great credit upon the author.

"Secondary Batteries for Light and Power" (see page 214), was a record of actual experience, by A. H. Bauer, of Baltimore, who has devoted special attention to this branch of the business since the first accumulators were brought to this country. It was a source of regret that the absence of the author prevented the propounding of many questions which would have added greatly to the value of the discussion which followed. Practical experience with secondary batteries is so limited that there is a general call for more light upon this interesting subject. It is gratifying to know that there is a prospect of further development at an early day.

The question of approving the standard wire gauge, reported upon favorably by the committee, was referred to council with power.

The report of the committee on monthly meetings was accepted, and on account of doubt as to the interpretation of the rules covering the proposed innovation, the committee was granted further time to perfect its plans. In order to finally settle the matter, Capt. Michaelis gave notice that at the next regular meeting he would present an amendment providing for more frequent meetings.

Among the gentlemen present were Capt. O. E. Michaelis, of the ordnance department, U. S. A., Troy, N. Y.; Prof C. A. Young, College of New Jersey, Princeton; Sidney F. Shelbourne, New York Electric Lines Co., N. Y.; F. W. Jones and M. M. Davis, United Lines Telegraph, N. Y.; Thomas D. Lockwood, American Bell Telephone Co., Boston; C. O Mailloux, A. A. Knudson, David E. Lain, New York; Frank L. and Ralph W. Pope, ELECTRICIAN AND ELECTRICAL ENGINEER, New York; T. C. Martin, Joseph Wetzler, and E. P. Thompson, *Electrical World*, New York.

The following is the board of officers for 1886–7:

President,
FRANK L. POPE.

Vice-Presidents,

D. H. BATES,	PROF. W. A. ANTHONY,
FRANCIS W. JONES,	THOMAS D. LOCKWOOD,
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PROF. EDWIN J. HOUSTON,	DAVID BROOKS,	SIDNEY F. SHELBOURNE,
CHARLES F. BRUSH,	T. C. MARTIN,	CAPT. O. E. MICHAELIS,
EDWARD WESTON,	GEO. M. PHELPS, JR.	PROF. CYRUS F. BRACKETT.
CHARLES L. BUCKINGHAM,	PROF. B. F. THOMAS,	CHARLES O. MAILLOUX.

Treasurer,	*Secretary,*
ROWLAND R. HAZARD.	RALPH W. POPE, 11 Wall Street, N. Y.

Preliminary arrangements have already been made by the committee for the holding of a meeting on the evening of June 8th. It will doubtless be held at the Mills building on Broad street, where supper will be served by the experienced electrical *restaurateur*, M. D'Orville. A suitable paper, or subject for discussion, will be presented, of which due notice will be given. The very satisfactory general meeting leads to the belief that much interest may be awakened by more frequent gatherings, at an hour which will permit the attendance of those who are fully engaged during the day.

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STRIKE AT THE EDISON MACHINE WORKS.

The New York *World* of May 20 gives the following version of the labor dispute which has resulted in the temporary closing of the Edison factories:

Thus far this week no work has been done in the shop of the Edison machine works in the old John Roach premises, No. 104 Goerck street, nor in the Edison works at Nos. 18 to 24 Bridge street, Brooklyn. Two weeks ago the men presented a set of demands to Supt Charles Batchelor. There were many of them, and the men asked for an immediate answer to them. They insisted that in the future nine hours should constitute a day's work, but that the present ten-hour rate of wages should remain in force; then double pay should be given for overwork. Further, that "piece" or sub-contract work should cease; also that in place of having one man attend to several machines, that one man should be hired to attend to each piece of machinery, and, lastly, that only union men should be employed. The demands were at once agreed to, pending the action of the board of directors of the company. The directors refused to insist upon the men joining the union, and this demand was waived. The hour demand and the double pay for overtime was granted, but the abolition of the piece-work system, and to hire a man for each machine, the directors flatly refused, and on Saturday this decision was made known to the force and a strike ordered for Monday morning. About three hundred and fifty men in all went out, including laborers and pattern makers and machinists.

Speaking of the situation yesterday, Mr. Batchelor said: "We have been paying off the men to-day, and when they have had a spell of idleness I guess they will come to work again. There are no men in the working world to-day better paid than the men who work in electric light and machine shops. Some of the mechanics get from $35 to $40 a week. To have one man to attend to several machines has always been the rule in the shop. Just suppose a shaft is put on the lathe and a tool is set at work cut ting, a man may sit for hours while the cut goes on, and yet the union insists that we shall do this simply because there are many men out of employment and they wish to see them all busy. Then of the piece-work. When a man is making the same thing over and over again, we make a contract with him and he goes on on his own hook. If he loafs or gets drunk he loses his own time, not ours, and the men make from 25 to 75 per cent more than they would on weekly wages. We agreed to ten hours pay for nine hours' work. We agreed to double pay for over-time, but when it came to having them insist upon our employing only union men we refused, because we only insist that he be a good workman before we set him on. The piece-work plan is the very best for the men—certainly for the better class of mechanics, who are on this part of the work—and yet they allow the laborers to vote to call them out. As for our works, we have stopped our contracts for the purchase of iron and copper, and we have made very satisfactory arrangements with all those from whom we had contracts. We can shut down for three months very easily now, and when we open up again it may be in some other place away from this city. In a smaller place there may be trouble about wages and there the men always win. They should in the great majority of cases, but here they go further and insist upon our managing our business in a certain way, regardless of the fact that we have other competitors in trade. If I could go around to my customers and get an advance of 25 per cent. on all my contracts, I would grant the demand of the men respecting piece-work to-morrow, but I would get out of such a business as soon as I could, for there is no telling where the demands may lead or end in the future. The strike will make no difference to the Edison electric light system, as the repair work may be done anywhere, and there are plenty of dynamos on hand, and more can be made anywhere after the men get the experience, and this would not take long with willing hands. The men now on can make more money than any new men could, and we are willing they should, but they think otherwise, and so we are at a standstill."

At the office of the Edison Electric Light Company, No. 65 Fifth avenue, the strike had been heard of, but the suggestion that the strike might lead to a stoppage of the electric lights in the city was laughed at. "We have all the patterns under our care," said one officer, "and can have the machines made and repaired where we will. Any machine shop can do the work, and we are in no wise connected with the Edison machine works beyond the fact that Mr. Edison is a large stockholder in it."

D. J. O'Dare, a member of the executive committee of the united machinists, who is also one of the strikers, said yesterday: "We know that we are in the right in this strike, and mean to hold out to the end, as we are sufficiently strong to fight the company for some months. The Edison company have been getting their work out at cheaper rates than any other company by at least 25 per cent. To illustrate the unfairness of the contract system, let me tell you this fact. In the New York shop, on the first floor, thirteen planers are run by two men. On the second floor six lathes are run by one man and an assistant, and in two other instances three lathes are run by one man, and four planers by two men. This is unjust, and we demand that there shall be one man to each lathe or planer. Do you know that if the Edison plant machinery gets out of order that none can repair it but us, and that such an accident would put out most of these electric lights. You see we have got the company there, and our position is a strong one. The men intend to behave orderly and in a proper manner."

NEW YORK ELECTRICAL SUBWAYS.

PRELIMINARY REPORT OF THE COMMISSION.

The surviving members of the Commission on Electrical Subways have submitted to the legislature, in compliance with senator Daly's resolution, the following official report of their experience:

"With regret we first refer to the death of our colleague and president, Mr. Charles E. Loew, and it may not be inappropriate to add in this connection, that in his death the Commission has lost a member of exceptional executive ability, and one who apparently was animated by the controlling object of selecting a system best suited to the requirements of the public, and of the electric companies."

"We formally organized as a board July 20, 1885. All corporations, private companies, or persons on record as controlling or operating electric conductors in the City of New York were then immediately notified to file with us within 60 days, as stipulated by the statute, maps or plans illustrating such underground systems as they would desire or prefer to construct and operate. Within that time but one response was made to this call, namely, that of the Metropolitan Telephone and Telegraph Company. But as their proposal did not refer to the general or inclusive use of any or all classes of electric conductors, being specifically applicable to telephonic service only, we could not regard it as coming within the scope contemplated by law. Therefore it devolved upon us to act under the alternative provisions of the statutes, namely, to select, devise, or cause to be devised, such a general plan as would meet the requirement of the act, and to cause the same to be constructed as soon as might be consistent with the convenient use thereof by the public; and to this end we have since been actively engaged, as will hereafter more fully appear.

"The following tabulation, showing the mileage of wire now operated in this city, is based on the statements made to us by the electric companies,

	Overhead Miles.	*Underground. Miles.*
Telephone	5,446	614
Telegraph	5,981	186
Electric light	431	56
Messenger service	1,099	....
Stock quotations	389	....
Miscellaneous	300	....
Police telegraph	60	....
Fire alarm	850	150
Total	14,556	1,006
Underground	1,006	
Grand total	15,562	

It is safe to assert, however, that an actual survey might considerably change this showing. Inventors, electricians, and engineers generally were invited by six days' public advertisement to submit plans and proposals pertinent to the subject, the individual incentive to which was the chance of adoption of a system from those presented. In reply to this invitation, 118 different plans have so far been submitted, of which up to the time of Mr. Loew's illness 105 had been classified and officially passed upon. Opportunity was frequently given to inventors, experts, and promoters of these plans, and also to the representatives of electric companies to orally describe their plans and express their views.

"The underground systems of Philadelphia, Washington and Chicago were personally examined by us during November, 1885, or rather such embryo systems as there exist. After having thus exhaustively taken up the different branches of procedure which, under the law and to the best of our belief and ability, seemed to promise the best results, we finally convened for conclusive action late in December of last year, and but for the untimely illness and death of our colleague we would undoubtedly ere this have reached a unanimous conclusion. Our future action, however, will now wait upon the appointment of his successor, to whom the results of our investigation will be submitted. The difficulties which surround the successful solution of the underground wire problem in this city are of an extent and magnitude of which the public, as voiced in the general press at least, have no adequate comprehension; but it does not appear to us as within the requirements of your resolution or the province of this statement to exhaustively go over the ground, technically or otherwise, except that we are prepared to say as a matter of belief due to our investigation and study of the subject, that we shall be able within a reasonable time after the present vacancy in our board is filled to submit a comprehensive plan of a system which will prove satisfactory to the public, not prohibitory or ruinous to the electric companies, and creditable to ourselves. Our action at least shall be due to the best comprehension of, and judgment upon the subject of which we are capable, as to act with less than complete confidence the outcome would appear to us as rash and unwise.

THEODORE MOSS, } *Commissioners.*
JACOB HESS, }

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VAN RYSSELBERGHE'S SYSTEM IN PRACTICE.

A European correspondent, who has facilities for obtaining reliable information, writes as follows:

Apropos of the Van Rysselberghe system for simultaneous telegraphy and telephony, which has received no little encouragement from the electricians of the daily press, some figures from the last report of the Belgian Telephone Company may not be uninteresting.

The official report of the company for 1885 shows that their working expenses for the trunk-line service during that year were 29,400f, and the gross revenue 5,400f, thus leaving a net loss of 24,000f. Besides this, the investment of the company in establishing the service was 60,000f, nearly all of which was spent in 1884, so that the system has had a full year of trial.

This trunk-line service in Belgium is worked by the government telegraph department in conjunction with the telephone company, the government furnishing the lines between towns, and taking four-fifths of the receipts, while the company performs the local service, connecting the subscribers and collecting the money, and receives one-fifth of the fees—one franc per conversation of five minutes.

The gross income of the government was, therefore, about 21,600f, or four times that of the company. As government departments are privileged to indulge in happy-go-lucky ways of bookkeeping, denied to common people, the official expenses are unknown, but it *is* known that all the telegraph batteries in Belgium had to be doubled to make up for the loss of current involved by this system, and it is doubtful if the gross revenue of the service was sufficient to pay for the maintenance of these extra batteries.

As for covering the wages of the employés engaged in watching the service and repairing troubles, or a reasonable interest on the cost of introducing the system, that is evidently out of the question. The entire cost of fitting up the Belgian telegraphs with the Van Rysselberghe apparatus is unknown to the public, but it is understood to have been some 300,000f for the lines between Antwerp and Brussels alone. The financial results are therefore somewhat disappointing, and it is not surprising that the directors of the company observe in their report that the service "does not afford satisfactory results."

The non-official telephonist, accustomed to trunk lines of 50 to 100 miles, when he learns that Antwerp and Brussels are but 27 miles apart, may wonder why a portion of the 300,000f was not applied to the building of a simple telephone line between the exchanges of those cities, thus attaining a good and satisfactory service without any bother with condensers and resistances and the doubling of telegraph batteries, and all the paraphernalia of the Van Rysselberghe system.

A KEELY MOTOR STOCKHOLDER.

Mrs. Belle Alexander, an elderly lady, of No. 104 Madison avenue, owned five shares of Keely motor stock, and waited in vain for any return from her investment. She was always told that the machine was about to be perfected, and that the last experiments were soon to show what a revolution was to take place in locomotive machinery. Mr. F. H. Reilly was the agent for the company at No. 115 Broadway. Not long ago the company abolished the office in this city.

Recently Mrs. Alexander has been visiting the old office very often to see how the stock was going and to inquire if she was to receive a dividend. These visits annoyed Mr. Reilly, and he informed the lady that he was no longer in the employ of the company, and that he wished her not to visit him again.

Mrs. Alexander obtained a summons for Mr. Reilly on a charge of assault and he appeared in court with his counsel. The lady then accused him of having struck her in the face when she called at his office.

Mr. Reilly resides at No. 427 Gates avenue. He denied all the charges, and said that whenever Mrs. Alexander called at his office he gave her all the information he could about the motor. She would take up a newspaper, sit in a chair, and read for hours in his office; then pester him with questions about what her share of the profits was to be. When he ceased to be agent for the company he told her so. He kept the office as agent for electrical appliances and other patents, and she continued to annoy him. He told her to go away and stay away. He also told the watchman in the building not to allow her to come to his office. He told the superintendent of the building, and that gentleman advised him to remove his office. A few days subsequently, Mr. Reilly said, she called again. He told her to leave, and proceeded to show her out the door, when she put her foot in the way and prevented the door from being closed. He went to push her, when she struck him with her umbrella and spat in his face, pulled his beard and scratched his face. She then tripped and fell. Mrs. Alexander did not deny that she had spat on Mr. Reilly and scratched his face because he offered her an insult, she said. In this Mr. Reilly said there was no truth.

Justice Gorman decided to postpone further hearing until next day. Mr. Reilly was paroled in custody of John H. V. Arnold, of No. 206 Broadway.

TAXES ASSESSED IN NEW YORK CITY UPON ELECTRICAL INTERESTS.

THE rate of municipal taxation in New York is $2.40 per $100. The following is a list of the amounts charged against the companies named. There are some inconsistencies in it, but the existing system of taxation is a very bungling affair:

American District Telegraph Co	$955 68
American Postal Telegraph Co	24 00
American Speaking Telephone Co	4 80
American Telegraph and Cable Co	18 00
Automatic Current Protector M'f'g Co	240 00
Brush Electric Illuminating Co	1,824 00
Central and South American Telegraph Co	11 16
Commercial Cable Co	240 00
Continental Telegraph Co	5 52
East Tennessee Telephone Co	7 20
Edison Lighting Co	3,824 30
Edison Electric Illuminating Co.	5,823 29
Edison Machine Works	1,204 41
Edison Ore Milling Co	84 00
Edison Shafting Manufacturing Co	120 00
Electric Reporting Co	48 00
Electric Tube Co	600 00
Electrical Review Publishing Co	90 00
Equitable Electric Co	4 80
Excelsior Electric Co	480 00
Gamewell Fire Alarm Telegraph Co	1,172 27
Gold and Stock Telegraph Co	1,220 41
Harlem District Telegraph Co	60 00
Holmes Burglar Alarm Telegraph Co	133 97
Holmes Electric Protective Co	558 22
Hudson River Telephone Co	29 02
Independent District Telegraph Co	10 39
International Ocean Telegraph Co	11 16
Leclanché Battery Co	120 00
Manhattan District Telegraph Co	446 58
Metropolitan Telephone and Telegraph Co	6,398 33
Mexican Telegraph Co	11 16
Mutual District Messenger Co	234 45
Mutual District Telegraph Co	1,114 21
National Telegraph Co	66 98
N. Y. Applegate Electric Matting Co	441 60
N. Y. Mutual Telegraph Co	552 16
N. Y. Telegraph Co	11 16
N. Y, and Pennsylvania Telegraph and Telephone Co	35 72
Orange and E. Orange District Telegraph Co	172 80
Railway Telegraph Co.	7 20
Southern Bell Telephone and Telegraph Co	11 16
Staten Island Telephone Co	38 85
Time Telegraph Co	1,804 80
U. S. Electric Lighting Co	5,889 60
U. S. Telephone Co. of Connecticut	96 00
U.S. Telephone Manufacturing Co	120 00
Westchester Telephone Co	36 00
Western Union Tel. Co	2,232 90
Total	$38,146 26

THE COMMERCIAL CABLE COMPANY'S RATES.

The following card has been issued by the general manager of the Mackay-Bennett cables:

Executive Offices, No. 40 Wall street,
New York, May 3, 1886.

To our Patrons:

We respectfully tender our thanks to those of our friends and customers who have notified us of their intention to support the Commercial Cable Company during the impending tariff contest. The very large number of communications which we have already received renders it impracticable for us to make separate acknowledgment to each. We trust, therefore, that all will accept this public announcement of our appreciation of the large and cordial support thus assured to us in advance.

A few of our friends have asked us what assurance of protection we can offer to them in case the patronage extended should not be sufficient to enable us to withstand the attack now made upon the company. Recognizing the propriety of such inquiry, we now announce that in the event of our being compelled to advance our rates *beyond those which we have heretofore charged*—40 cents per word—we will refund the amount of excess that may have been paid to us during the continuance of the struggle, viz.: the difference between 12 and 25 cents per word between America and Great Britain and France, and the difference between 15 and 25 cents between America and Germany.

GEO. G. WARD,
Secretary and General Manager.

EDWARD H. GOFF VINDICATED.

There have appeared at various times in the daily newspapers insinuations against the business reputation of President Goff, of the American Electric Manufacturing Company, on account of certain financial transactions in connection with the Agricultural Insurance Company of Montreal. An attempt has been made to extradite him on the charge of forging the minutes of a meeting. The hearing before the United States court of this district, which continued for some weeks, has resulted in the dismissal of the case, and the opinion of U. S. Commissioner Osborn, given at considerable length, seems to confirm the previous statements of Mr. Goff, that the charges were based upon an attempt to injure and annoy him rather than to further the ends of justice. Mr. Goff is fairly entitled to the congratulations of his friends upon his successful defense from an attack which appears to have had no legitimate foundation.

SUBTERRANEAN LINES.

The Continental Conduit Co. has been incorporated in New York by John D. Beers, J. Pierson Grant, Eugene W. Austin, Charles D. Judd and Edward B. Thomas. The capital is $2,000,000 and the objects are to manufacture conduits for telegraph, telephone, electric light and other electric conductors separately, or in combination with sewer, water, gas, steam and other service.

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ELECTRIC LIGHT AND POWER.

The Jarvis Engineering Company, of Boston, has had an application from one of the largest electric lighting companies in this country to apply its system of erecting steam plants in Europe in connection with their lights. One of the principal reasons of the failures of introducing electric lights successfully abroad has been the cost of producing power. There is plenty of slack coal to be had for fuel. At the present time, with the style of boilers, engines, pumps, etc., in use all over Europe, there is very little profit in the business.

The Salem Electric Light Company will contract with the city for three years to furnish everything, the lights to be of 2,000 candle power, 75 lights at 50 cents each per night, all over 90 and up to 100 at 48 cents each, and all above at 45 cents. The 75 lights do away with 85 oil and 285 gas lamps. The cost in 1885 of these lamps was $8,177. The city could erect a complete electric light plant for less than $30,000, and the cost per light would be $26.77 per year, or 29$\frac{3}{10}$ cents per night. The city could also light city hall and the police station with the incandescent light for 27 cents per night. This system could be in operation by July.

An incandescent dynamo of 200 16-candle power lights capacity has been placed in the Bay State Sugar Refinery, Boston.

The battle in Detroit between the Brush and the Thomson-Houston electric light companies was waged with all the earnestness of a continental strife. Some hot shot was delivered by both sides, but the hottest thing was the undisputed statement of a London scientist, whom the common council had brought upon the scene—that the arc lights of which 2,000 candle power was claimed never produced 500 candle power.

The paper read before the National Electric Light Convention, held in Baltimore last February, by A. F. Upton, general manager of the Jarvis Engineering Company of Boston, on the transmission of power by electricity, attracted considerable attention all over the country among electric light companies, and has resulted in the application of this system by the following companies: Edison Illuminating Company, New Bedford Mass.; Milford Electric Light and Power Company; Taunton Electric Light Company; Edison Illuminating Company, Boston. There is more money in selling power by this system than in selling electric lights.

The Electrical Railway and Power Company, of St. Louis, has been organized, and is now ready to introduce its appliances for supplying motive power, electric light, or to fully equip and operate electric railways. Numbered among the stockholders are some of the most prominent business men of this city. Mr. John Jackson is president; Chas. Hoyle, secretary and treasurer.

The Brush-Swan Electric Light Company, of Norfolk, Va., have erected a 75 h. p. Westinghouse engine to take the place of three other automatic engines heretofore used. The Westinghouse engine is mounted on a pedestal and coupled right and left to shafts carried over the horizontal engines, which are reserved for daylight circuits, or as relays in a case of accident.

The Hydro Electric Railway Motor Company, Chicago, Ill., has been incorporated with a capital stock of $500,000. Charles Wondries, Jr., and others are the incorporators.

The councils of Newport, R. I., have extended for three years the city's contract with the Thomson-Houston Electric Light Co., of Boston, Mass. This system succeeded the Weston, in Newport, about a year ago, after a lengthy contest.

The Shamokin, Pa., Gas Light Co. has passed into the control of the local electric lighting company which will combine the two systems of lighting. The electric system in use is the Edison incandescent. Shamokin has about 15,000 population.

An electric light plant is being established at Rome, with a total of 12,000 incandescent lamps.

An electric light plant is to be put in at Jackson, Tenn. Cost, $15,000. Address, Anderson and Searby, Jackson, Tenn.

NEW CORPORATIONS.

The Continental Electrical Co., New York city. Capital stock, $500,000. Frederick H. Allen, 40 Exchange place, and others, incorporators.

The Strong Telephone Co., Chicago, Ill. Capital stock, $200,000. William P. Black and others, incorporators.

The Roberts-Brevoort Electric Co., New York city. Capital stock, $100,000. Henry E. Brevoort, 206 Broadway and others, incorporators.

The Cambridge Electric Co., Cambridge, Mass. Capital stock, $60,000. John E. Burgess and others, incorporators.

The Automatic Electric Current Arrester Co., of New York city. Capital stock, $100,000. Isaiah Paxson and others incorporators.

The Kingston and Rondout Electric Light Co., Kingston, N.Y. Capital stock, $30,000. George W. Blanchard and others, incorporators.

The Minneapolis Electrical Supply Co., Minneapolis, Minn. Capital stock, $60,000. Elwood S. Corser and others, incorporators.

The Green Bay and Fort Howard Electric Light Co., Green Bay, Wis. Capital stock, $20,000. George W. Lamb and others, incorporators.

The East End Electric Light Co., Pittsburg, Pa. Capital stock, $50,000. W. R. Kuhn, treasurer; J. A. Emery, 131 Fifth avenue, attorney.

The American Cushman Telephone Co., Chicago, Ill. Capital stock, $500,000. Chas. N. Holden and others, incorporators.

The Aurora Telephone Co., Aurora, Ill, Capital stock, $10,000. Willis Hoyt and others, incorporators.

The Mahoning Electric Light Co., Youngstown, O. Capital stock, $40,000. Thomas H. Wells and others, incorporators.

The Gibson Electric Co., New York city. Capital stock, $100,000. John M. Clarke and others, incorporators.

The Automatic Electric Protector Co., Chicago, Ill. Capital stock, $200,000. George G. Allen and others, incorporators.

The Porter Electric Messenger Co., New York city. Capital stock, $100,000. James Hepenstall and others, incorporators.

The Danbury Schuyler Electric Light Co., Danbury, Conn. Capital stock, $75,000. Henry Bernd and others, incorporators.

The Edison Electric Light and Power Co., Erie, Pa. Capital stock, $60,000.

The Acme Incandescent Lamp Co., Portland, Me. Capital stock, $500,000. Samuel B. Wilcox, Boston, Mass., and Henry A. Gustavson, Chelsea, Mass., incorporators.

The National Electric Mail Box Manufacturing Co., Camden, capital stock, $100,000, has been incorporated by Samuel W. Wray and others.

The McDonough Telephone Company, of New York city. Capital stock, $5,000,000. George W. Beavers, and others, incorporators.

The Taylor Telephone Company, Buffalo, N. Y. Capital stock, $20,000. Thomas B. Englehart, and others, incorporators.

The Western Commuters' Telegraph Company has been organized at Chicago, Ill. Capital stock, $500,000. George W. Cass, 99 Washington street, and others, incorporators.

The Van Choate Electric Light Co. has been incorporated, with a capital of $5,000,000, divided into 50,000 shares. Its incorporators are Alexander C. Cary, Henry Belden, Robert N. Woodworth, Henry E. Parsons, George F. Johnson, Howard B. Woodworth, and Arthur H. Lowerre.

THE STANDARD UNDERGROUND CABLE COMPANY.

At a stockholders' meeting of the Standard Underground Cable Company, held May 22d, the following board of directors was elected: George Westinghouse, C. H. Jackson, Robert Pitcairn, John H. Dalzell, M. W. Watson, O. T. Waring, and R. S. Waring.

The company has recently secured several important contracts, while its general business is growing very rapidly, and points to the necessity of an early increase in manufacturing facilities.

PERSONAL MENTION.

W. D. Sargent, general manager of the New York and New Jersey Telephone Co., returned on April 25th from his trip to Nassau, N. P. His health is much improved, and he is now actively engaged in his usual duties.

Fred. H. Angell has made an engagement with Clark B. Hotchkiss, general agent for A. G. Day's kerite wire and cables, and will, therefore, continue to supply his friends with good insulated wire.

Thomas Pray, Jr., long known to readers of trade journals as having occupied several important editorial positions, has accepted a situation as general superintendent of the Mather Electric Co., of Hartford, Conn. Mr. Pray has evinced a decided taste for the electrical field, and his thorough mechanical knowledge will prove of great assistance to him.

TELEPHONE.

Solicitor-general Goode has retained the following named gentlemen as special counsel, to assist in the government telephone suit: Hon. A. G. Thurman, of Ohio, Grosvenor P. Lowrey, of New York, and Eppa Hunton, Jeff. Chandler and C. S. Whitman, of Washington. The case will be argued at Columbus, Ohio.

The Meucci Telephone Co. has been organized at Elizabeth, N. J., and the following officers elected: President, Mr. Seth B. Ryder; vice-president, Mr. John E. Voorhees, and secretary and treasurer, Mr. James R. English. The new company is composed almost entirely of residents of that city, who have entered into this enterprise expecting to secure better facilities and cheaper rates. The privileges of erecting the lines and carrying on the business has been granted by the city council, and the new company has already established an exchange.

Four new iron wires have lately been erected by the post-office between London, Manchester, and Liverpool, on the "twist" or anti-induction principle. Some telephonic experiments were carried on between these places, but speaking was found to be practically impossible.

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AND
ELECTRICAL ENGINEER.

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Communications *suitable for our columns will be welcomed from any quarter. Discussions of subjects relating to all branches of electro-technical work, by persons practically acquainted with them, are especially desired. Unavailable and rejected manuscripts will be returned only when accompanied by the necessary postage.*

Advertisements.—*We can entertain no proposition to publish anything for pay, or in consideration of advertising patronage, except in our advertising columns. Our editorial columns will express our own opinions only, and we shall present in other columns only such matter as we consider of interest or value to our readers*

NEW YORK, JULY, 1886.

INCANDESCENT LAMP LITIGATION.

MORE than a year has elapsed since the Edison Electric Light Company commenced a large number of suits against the United States Electric Lighting Company, the Consolidated and the Swan Incandescent Electric Light companies, and sundry other parties, alleging an infringement upon the patents of the Edison company relating to incandescent lighting, and asserting that patents of Mr. Edison covered the exclusive right to manufacture, sell and use in the United States, any and all practical incandescent electric lamps. Up to the present time, so far as we are able to learn, very little progress has been made in carrying on this litigation; indeed, we believe that no testimony has yet been taken in any of the cases, so that it appears probable that a long time will elapse before any definite conclusion is reached in court as to the validity and scope of the Edison patents.

On the other side of the Atlantic, however, the legal proceedings have apparently been carried on much more energetically than in this country, and a decision has recently been reached upon certain points of considerable importance. In Great Britain the patents of Edison, Swan, Sawyer and Man, and Gimingham, are all owned by the Edison and Swan United Electric Light Company. This concern sued the firm of Woodhouse and Rawson, electric engineers and contractors, who have for some time carried on a very extensive business in the installation of electric light plants, alleging an infringement of the company's patents. Two independent suits were brought, the first relating to the general construction of the incandescent lamp, and the second to the process of treating the carbons by heat, in a carbonaceous atmosphere. The first suit alleged an infringement of three patents; the first of Edison, November 10th, 1879, which is essentially the same as United States patent No. 223,898 of January 27th, 1880; the second of Swan, of January 2d, 1880, for the now well-known method of eliminating occluded gases by heating the carbon by an electric current, and at the same time working the vacuum pumps, and the third of Gimingham, September 29th, 1881, for a particular method of attaching the carbon to the conducting wires, which consists in forming the ends of the latter into elastic spirals into which the tips of the carbon are inserted. The presiding judge, Mr. Justice Butt, at an early stage of the proceedings intimated that the evidence was insufficient to establish infringement either of the Gimingham or the Swan patents, and, consequently, these practically disappeared from the case. It was not alleged by the complainant that the last two claims of the Edison patent were infringed, so that the case ultimately turned on the question of the infringement of the remaining claims, one of which is for "an electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance, made as described, and secured to metallic wires as set forth," and the other for "the combination of a carbon filament with a receiver made entirely of glass, through which the leading-in wires pass, and from which the air is exhausted, for the purposes set forth." The "filament" referred to in the first claim is described in the specification as being formed by the carbonization of material previously prepared in the form of a thread or wire as it is intended to be used. We find no evidence in the case as to the actual method of manufacture employed by Woodhouse and Rawson, but it is generally understood that they do not make their filament in that way; hence the really important claim in this case was the second, which, as contended by the complainant gave it the sole right to manufacture incandescent lamps in which any carbon filament, however formed, is contained in an exhausted glass globe through which the connecting wires are made to pass. In order to interpret the claim, it first became necessary to determine the legal signification of the term "filament." In opening the complainant's case, Sir Richard Webster explained that the difference between Edison's incandescent conductor and those which were known prior to his invention, was that he carbonized a thread, instead of reducing a stick already carbonized to the smallest possible cross-section. The carbon filament was the thing which he intended to claim and protect. The idea of shaping the conductor first, and then carbonizing, was the root of the discovery which led to the success of Mr. Edison's lamp. Mr. Aston, for the complainant, contended that the essential characteristics of a filament were flexibility, elasticity and thinness, but even if the word filament implied thinness only, it was nevertheless quite sufficient to distinguish Edison's lamp from any of its predecessors. Mr. Justice Butt, in delivering his opinion, in substance said that the infringement of the Swan and Gimingham patents had not been proven, and hence the validity of these patents was beyond the sphere of the present inquiry. Neither, in his opinion, had there been an infringement of the first claim of Edison's patent, but in the view which he took of the second claim, that inquiry became unimportant. The question of the infringement of the second claim depended upon the precise meaning to be attached to the words

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"a carbon filament." If the meaning of the term were restricted to a particular filament as described in the patent, the claim would not be infringed, but he did not so interpret it; he held the claim to mean any carbon filament, however made, possessing certain qualities or properties mentioned in the specification, or necessarily resulting from the description there given; that is, the carbon filament must possess flexibility and resiliency, must be of small cross-section, offering a high degree of resistance to the passage of the electric current, and must present but a small surface from which radiation of light could take place. He was disposed also to think, although he refrained from giving a decided opinion, that the resistance must not be less than 100 ohms. Upon this interpretation it was clear that the defendants infringed the second claim. The judge then proceeded to examine the defenses which had been put in to invalidate the patent. Mr. Charles, the defendants' solicitor, contended in substance that the claim was too broad; that the specification was insufficient; that the lamp described was not a good one, and that at the date of the final specification Edison knew of a better method of making the filament, inasmuch as a more efficient process had been described by him in the provisional specification of another application bearing an earlier date than the final specification of the patent under consideration. The judge apparently attached but little importance to the first three objections, but considered the last one more seriously, finally overruling it on the ground that the patent did not claim any particular method of making the filament, and in fact could not legally have claimed the improved method, as it was not set out in the provisional specification. Among the anticipatory inventions brought forward by the defense were the lamps of Lane-Fox and Pulvermacher, and the experiments of Sidot in carbonizing vegetable fibre. An early lamp of Swan's which had been publicly exhibited but not patented, was put in evidence, which was provided with a carbon rod or pencil. This device in the opinion of the judge did not constitute a filament. It is worthy of remark that Mr. Swan was not produced as a witness, in connection with which it may be remembered that he has publicly stated that he made experiments with carbonized paper as long ago as 1860 or 1861, and that he made a carbon wire "steel-like in its elasticity" and 1–100 of an inch thick, which he used with some degree of success.

The decision was for the complainant on the Edison patent, and for the defendants on the Swan and Gimingham patents.

The second case related to the infringement of a patent of Sawyer and Man, of November 28th, 1878, amended by a disclaimer of November 12th, 1884, which corresponds in substance to United States patent No. 211,-262, of January 7, 1879, of the same inventors.

The first claim of this patent is for the described method of preparing the illuminating part of an electric lamp, which consists in "electrically heating the same while surrounded by a carbon gas or liquid;" the second is for a material for the manufacture of illuminating conductors of electric lamps, produced by electrically heating carbon in a carbon gas; and the third for a described method of preparing the illuminating part of an electric lamp, "consisting in first obtaining a solid deposit of carbon by electric action as set forth, and subsequently, when the globe containing it is charged with a carbon preservative atmosphere, and before the lamp is finally sealed, heating the illuminating part by means of the electric current in order to expel impurities and occluded gases." These claims will be recognized as covering the well-known hydrocarbon gas process of treating incandescent filaments in order to increase their density and render them of uniform resistance throughout their length. Practically the defense did not deny the commission of the infringement, but contended that the patent was invalid for want of novelty. Among other defenses which were put in were certain published accounts of experiments made by Grove in 1845, Despretz in 1849, and Sidot in 1870. The judge held that the first of these alleged anticipations had no bearing on the case. The experiments of Despretz were designed to show that carbon was capable of being fused and vaporized, and this was accomplished by passing a powerful electric current through carbon conductors and obtaining on them a coating of carbon. The judge said that Despretz produced a material in substance very like, if not identical, with that used for the Sawyer and Man conductor, but he thought the defendants had failed to show that the Despretz process would obtain one very important result, namely: the filling up of the pores of the carbon. The patentee effected this by gradually increasing the electric current and consequently the temperature, while Despretz used the same electric force at once and continuously. He accordingly held that the Despretz process was different from that of Sawyer and Man, and did not anticipate it, for the reason that it was not and did not even suggest a practical process for producing incandescent filaments. He therefore affirmed the validity of the patent and found for the complainants. It gives us satisfaction to remark, in reviewing this decision, that we have been much impressed with the intelligent and conscientious endeavors of the judge to determine the true bearing of the evidence, and to confine the testimony strictly to the issue, avoiding so far as possible all confusion of the real question by the discussion of legal technicalities. It is seldom that a case which presents so many difficulties is handled with so much ability and impartiality, not only on the part of the judge, but of the learned counsel on both sides. It may be said however, that the defense apparently failed to fortify itself as strongly as it might have done in some respects. In the matter of expert testimony especially, the complainants seem to have had the advantage.

The publication of these decisions has excited considerable interest in electric lighting circles in this country, and many inquiries have been made as to their effect upon the status of the present and prospective litigation in the United States relating to the same subject. So far as the Edison patents are concerned, it may safely be said that the decision can have no effect whatever. In a carefully prepared article, which we published a year ago (Electrician and Electrical Engineer, vol. iv., p. 244), we showed that the United States patent of Edison which corresponds to

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the British patent on which the decision was based, expired and became public property on November 17th, 1884, under the operation of the statute of limitation, and the decision, therefore, merely emphasizes the fact that certain inventions claimed in the patent are public property in the United States so far as Edison is concerned. In respect to the invention covered by the Sawyer and Man patent the case is quite different. The foreign decision establishes the novelty of the invention, that is to say, that it was not known in Great Britain and had not been described in printed publications prior to the date of the patent. In the United States, however, some time subsequent to the issue of the Sawyer and Man patent, a conflicting application for a patent for the same invention was made by Edward Weston. An interference was declared and stubbornly contested in the Patent Office at every step, the final result of which was a judgment of priority in favor of Weston, and the issue of a patent to him on October 21st, 1884 (No. 306,980), covering the same invention which by the English decision was adjudged to have been first made by Sawyer and Man. Hence, so far as the decision in this case has any effect in this country, it tends to establish the validity of the Weston patent for the treatment of carbons by the hydrocarbon process. It cannot have any effect upon the status of the United States patent of Sawyer and Man, as that has already been passed upon in the Patent Office. When either of these patents comes before the courts in this country, inquiry will necessarily be directed anew to the question of priority as between Weston and Sawyer and Man, although the question of novelty will, of course, again have to be passed upon, if called in question by the defense.

The U. S. patent of Sawyer and Man is owned by the Consolidated Electric Light Company, and we understand that a suit is now pending against the Edison company and others for its infringement. A suit has also been brought by the same company against the Edison company on the fibrous carbon filament patent of Sawyer and Man, which will involve much the same issues as the suit on the British Edison patent. We shall endeavor to keep our readers informed of the progress and prospects of this important litigation.

THE TELEPHONE CASE AT NEW ORLEANS.

In our present issue we print the full text of the decision filed May 31st, by the U. S. Circuit Court at New Orleans, in the suit of the American Bell Telephone Co. against the National Improved Telephone Co.

The decision is virtually against the Pan-Electric Co. Preceded a few days by the extraordinary final and conscientious affidavit of the eccentric ex-examiner Wilber offered to the congressional investigation committee, and followed by the present dissensions among the Pan-Electric promoters, this decree of Judges Pardee and Billings doubtless indicates a complete collapse, at no very distant day, of the remarkable attack upon the Bell patent which has engaged public attention so greatly during the past year.

The failure of the Pan-Electric people to avoid an injunction pending the trial of the government suit is the most immediately valuable result of the New Orleans case to the owners of the Bell patents. The court, having before it not only the evidence used in the several previous suits won by the American Bell Telephone Co., but also, all the testimony presented to the Secretary of the Interior in the hearing of last winter, upon the application for bringing the government's suit to annul Bell's patent, has not only granted an injunction on the sufficient ground of the Pittsburg decree against the same defendant, but has considered the case in many aspects. In a compact and terse opinion the court has given its judgment upon all the issues raised by the Pan-Electric instigators of the attack upon the Bell patent.

The opinion of the court, briefly summarized, is as follows:

1. That the National Improved Telephone Co. is bound and concluded by the final decree rendered at Pittsburg.
2. That the pendency of the government suit to annul Bell's patent is not and cannot be a bar to the granting of injunctions.
3. That Bell's apparatus, as described and illustrated in his original application, will transmit articulate speech in the manner described by Bell.
4. That Bell's invention clearly antedates Gray's claims; Gray, by his own testimony, not having conceived the idea embodied in his caveat till at least twenty days after Bell had drawn up, signed and sworn to his application.
5. That in all the evidence, including that laid before the Secretary of the Interior, "we have found nothing that shows that Bell has done or caused to be done anything inconsistent with his right to be called an honest man—with clean hands."
6. That the instruments used by the National Improved Telephone Co. infringe the patent granted Alexander Graham Bell in 1876.
7. That Reis never produced a speaking telephone, and that the transmission of speech by his method is a physical impossibility.
8. That although Reis's instruments and methods were well known in the scientific world, and were manufactured and on sale in the chief capitals of Europe; yet before Bell's invention of 1876, there was no speaking telephone in use, nor any pretence of any.

Unless the Pan-Electric Co. and its co-adjutors in the attack upon the Bell patent can produce more and better evidence than they have so far offered, their chance of enriching themselves in the telephone business would seem small indeed. The public has been humbugged long enough by the persistent allegations of fraud on the part of Prof. Bell in obtaining his patent. Wilber's last affidavit would seem to be sufficient to disabuse the average mind of any lingering belief in the charges. Yet, for the honor of personal character and scientific attainment, it is very gratifying that Judges Pardee and Billings should declare their conviction that nothing in the record impugns the character or soils the hands of Alexander Graham Bell.

It is deserving of notice that the court thought it worth while in delivering its opinion, to assert that it was convinced "through its own senses" that the transmission of speech had been completely attained by means of the apparatus shown in Bell's famous figure No. 7. The court's further judicial opinion that the Reis invention is inherently incapable of transmitting articulate speech is also a point of interest. In view of the strenuous efforts put forth by the defendants in the case, the scope of the evidence submitted, and the careful and deliberate consideration given by the court, the opinion and decree of the court at New Orleans would seem to denote a very marked fall in the prospects of the Pan-Electric people for breaking down the Bell patents.

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ARTICLES.

PRACTICAL DYNAMO BUILDING FOR AMATEURS.[1]

(Concluded from page 214.)

THE COMMUTATOR.

The commutator next demands our attention, and its arrangement upon the spindle is shown in figure 10 ; also an end view of the segments after the building and turning has been finished, in figure 9 (purposely made on an enlarged scale). The first thing that has to be done is to make a pattern of the commutator strips, A, figure 9, and to do this properly a circle must be drawn, slightly larger in diameter than the finished commutator, and an inner circle smaller than the bore, to allow of the final tooling. Divide this circle into 48 divisions, great care being taken that the dividing be accurately performed. Then on each side of the penciled dividing lines draw a parallel pair of lines to represent $\frac{1}{32}$ inch of insulation strip between each bar. It must be remembered that in building up the commutator the intervening insulation does *not* taper towards the centre ; therefore, to avoid a lot of filing, the parallel lines will commence $\frac{1}{64}$ inch away from the dividing or centre line upon the outer circle, and run parallel right down.

To make the pattern, twelve slips of wood, A, figure 9, are cut, and planed off so that the section corresponds exactly with the division upon the circle. Each piece may be nicked on each side, to facilitate breaking off, and then should be sand-papered, so that there remain no rough edges to form an excuse for a bad casting.

The metal for commutators should be hard brass, or phosphor bronze if the latter is obtainable, for there is more wear upon this part of a dynamo than on any other, and certainly it is the most troublesome to replace.

When the castings are finished and cut off at the nicks, the pieces should be pickled in brass finisher's "dip," to clean the sand and roughness from the surface, and then filed up if they require it. A sheet of asbestos millboard, $\frac{1}{16}$ inch in thickness, must be obtained, and this should be chosen of a close grain, and clean, incisive cut. Mica is a better substance for this purpose, but is neither so cheap nor so easy to work as asbestos card.

Forty-eight slips may be cut rather larger than the commutator bars, and then placed in an oven, or similar apparatus, until all the moisture has evaporated.

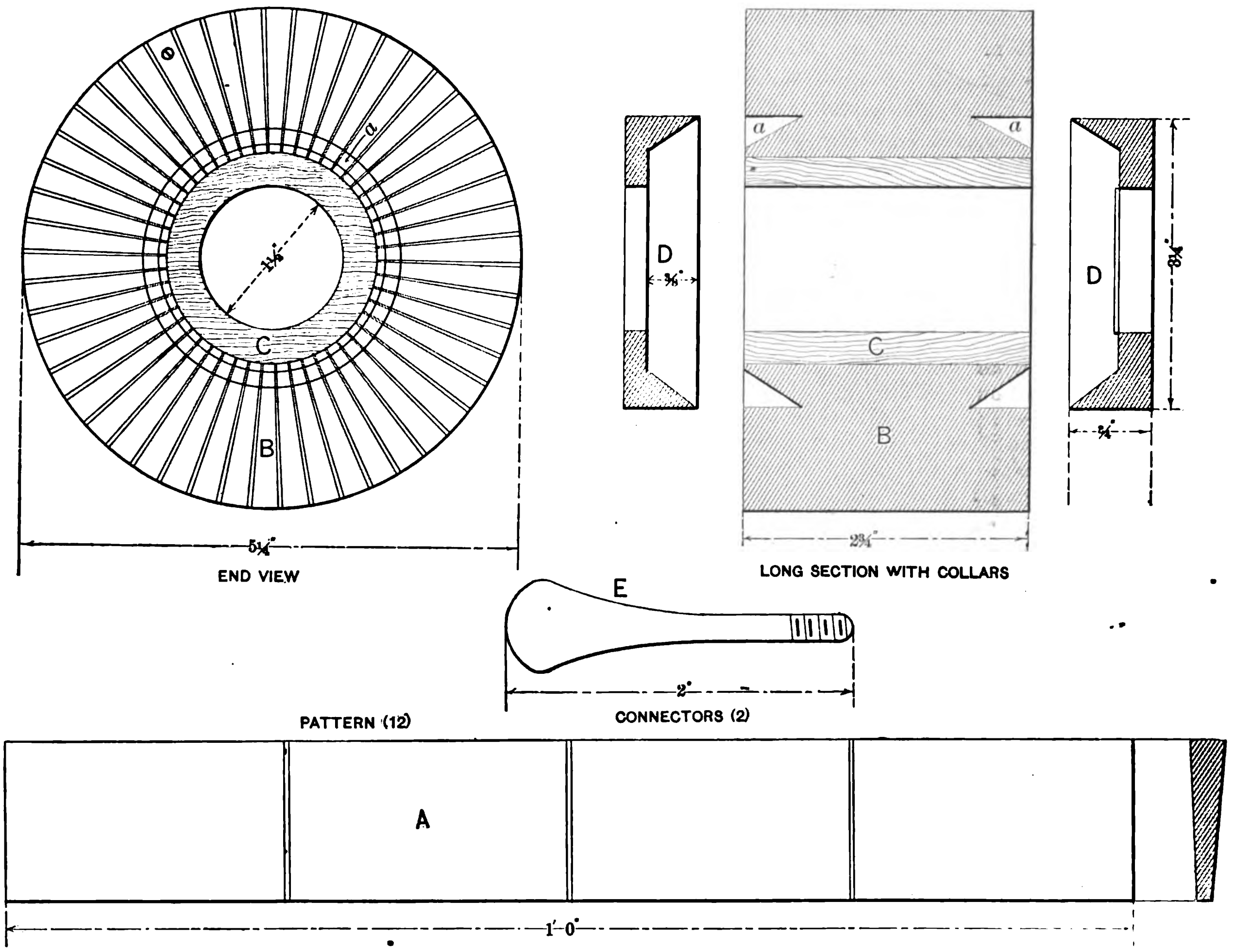

Figure 9.

A piece of iron, $\frac{1}{4}$ inch thick and $2\frac{3}{4}$ in. wide, must be bent round so as to form a circular cramp, having two lugs bent up, which are drilled and fitted with two $\frac{1}{2}$ inch bolts and nuts. When the cramp is drawn together so that the lugs meet, or nearly so, the internal diameter should be $5\frac{1}{4}$ inches, and the interior perfectly circular.

Slacking the bolts, and wedging the lugs apart, the strips may now be placed inside, with a slip of asbestos card between each, and when the whole of them are thus arranged, any distortion of the circle near the lugs of the cramp may be rectified by driving wooden packings between the cramp and commutator while screwing up. Even if the distortion seems beyond rectification, there is hope, for the turning will bring the whole into proper shape, if it is not too bad to allow of cleaning up.

The commutator is now ready for the lathe, and should be fixed to the face-plate by the cramp, bored out to receive the wooden bush C, figure 9, and the angular recess, *a*, turned

1. *English Mechanic.*

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in the face, which may be skimmed up as far as the cramp will allow. This recess *a* is made to suit the gun metal rings D, and should be quite a loose fit, all edges avoided, and nicely rounded off. Turning the commutator round upon the face-plate, a turned ring should be interposed so that this second chucking should be true with the first. The facing should this time be to size, and be carried, as before as far as the cramp will allow; the recess will be similar to the other, and then the commutator will be ready for fixing upon the spindle. Now, taking the spindle, run the end nut off, and thread upon it one of the rings D, then a large washer of calico (unbleached), then a similar one of asbestos paper, then another calico, then asbestos and calico washers again, and then the commutator with the cramp still upon it, taking care that none of the turnings, or metal dust, are interposed anywhere. The wood bush C is, of course, driven into the commutator previously. Then the alternate calico and asbestos washers are repeated, the second ring D, and the nut end, which must then be screwed up hard, forcing the insulation washers of calico and asbestos into the recess, and allowing the rings D to draw the commutator bars tightly to the shaft without making metallic contact. The end and back nuts on the spindle should be so arranged that when the end one is screwed hard up its exterior face will form a shoulder for the journal; then, putting the spindle between centres in the lathe, the commutator may be turned over the top (taking the cramp away), the sides faced down, and just finished with a second-cut file and quick speed. Heavy cuts should never be put upon a commutator, neither in boring nor turning, for if it does not actually shift it, there is considerable risk of doing so.

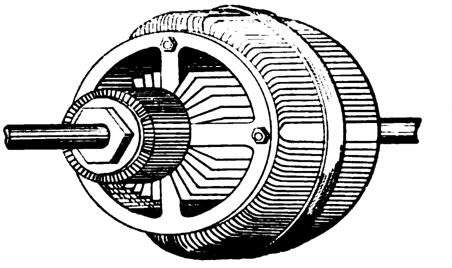

FIGURE 10.

The next thing is to test the bars individually for a possible "short circuit." Sometimes this may occur through a little piece, or pieces, of turning dust getting imbedded in the asbestos insulation, and so putting the two bars in metallic contact. In practice this is frequently "blown out" by a high E. M. F. which is used for testing; but this is not a safe proceeding, nor are the appliances ready to the amateur's hand as a rule; so a careful inspection, and any metal dust picked out with a sharp scriber, will doubtless remove the fault.

The asbestos insulation, which was $\frac{1}{16}$ inch in thickness, will now be found to be $\frac{1}{32}$ inch only on account of the pressure, and the exclusion of the moisture with which it is always surcharged when delivered from the warehouses, as it will, when large surfaces are exposed to the air, take up a quantity of water.

Care should be taken not to trim off the edges of the calico and asbestos washers too close to the rings, as it will frequently draw in and cause a "short-circuiting," or else a "body contact."

After testing the commutator again for the latter (which is a serious misfortune, if it occurs, because the cramp must be replaced, the commutator taken off and examined, and it will inevitably require turning again when replaced) the connectors, E, figure 9, will be the next piece of work.

These connectors, 48 in number, are made of 12 B.W.G. bare copper wire, and are cut off 2 inches, flattened and screwed at the ends, as shown. A small ladle should be put upon the fire, and some hard solder melted in it, and two gallipots placed handy, one containing "dipping acid," or spent nitric, and the other chloride of zinc, or, as it is usually called, "soldering fluid," or "killed spirits of salts."

Holding the screwed end of the connectors by means of a pair of plyers, dip the flat part into the "dipping acid," wipe, then into the chloride of zinc, and thence into the melted solder. By this method the connectors are readily "tinned" for soldering. With the commutator upon the spindle in the lathe, a slight mark should be made all round, $\frac{3}{16}$ inch away from the armature end. A fixed scriber will do this effectually.

Upon this line a centre dot should be marked, in the centre of each bar, and a tapping hole drilled $\frac{3}{8}$ inch deep, and to suit the above connectors in each end, all round, care being taken to keep the line of the drill radial with the commutator centre, so as not to drill through into another bar.

Before screwing the connectors in, however, the armature must be put in position upon the spindle, and the wheel end that comes next to the commutator should have all its inner edges nicely rounded, and a broad ring of vulcanized fibre $\frac{1}{16}$ inch thick cut to go between it and the armature coils, to prevent any possible body contact. The coil ends should be neatly parted off into six sets of eight in each, so as to pass through the spokes of the wheel end. These wheel ends should not be tightly screwed up to the armature body until they are in position upon the spindle, and keyed up permanently. Then the ends of the studs may be cut off and trimmed up, and slightly burred to keep the nuts from working loose. The coil ends are carefully bent so that they do not press hard against the wheel end, and the whole placed in the lathe. The connectors

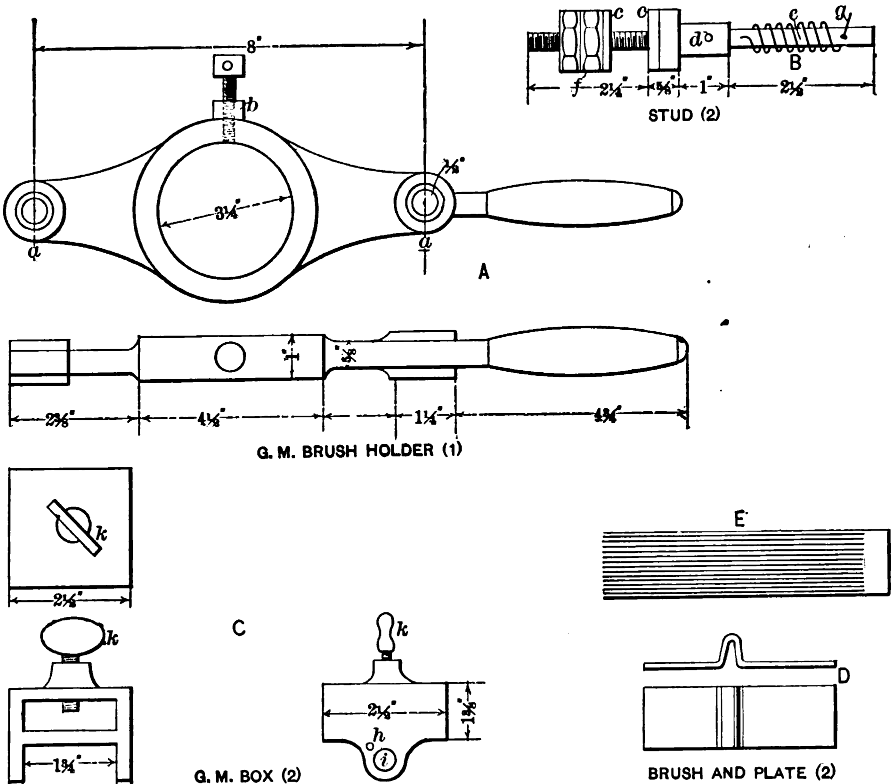

FIGURE 11.

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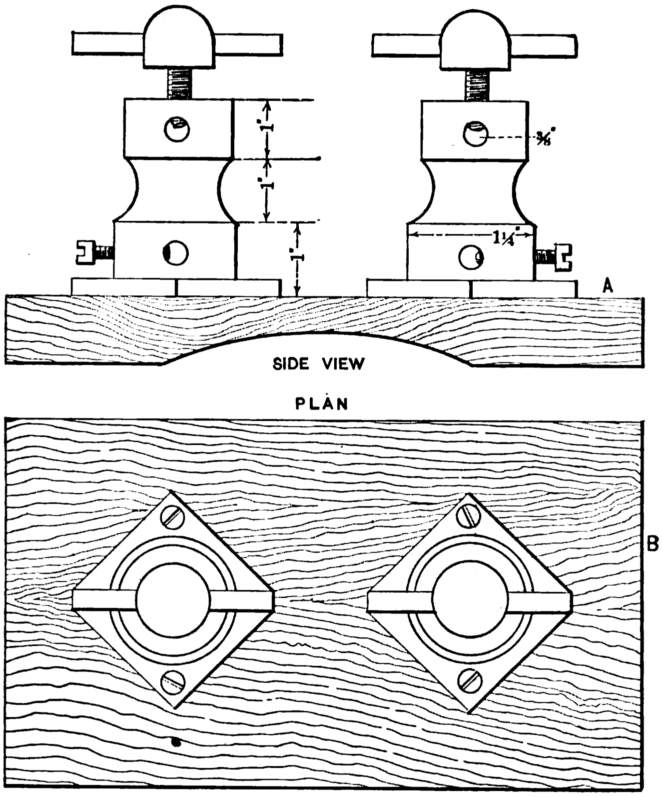
are now screwed in, each with its flat against a coil end, then spinning the whole against a fixed scriber; they should be slightly bent back, so as to give them a *convex* appearance when running, and set perfectly true, and cut off uniformly. Every connector is now turned over its adjacent coil end, and closely nipped round it, and, as both are well tinned, the joint is easily "sweated" with plenty of rosin and a hot iron. A little touch of zinc white improves the appearance of the connections and sets off the whole armature. The latter may be covered over and laid aside until the field-magnets are wound and the brush-holder finished.

BRUSH-HOLDER.

This is shown in detail on figure 11, A being plan and elevation of the holder proper. The centre is bored out to fit the boss K of the bearing end D, figure 2, and a small boss is provided at *b* for a set screw, so that the angle of



TERMINAL PLATE

FIGURE 12.

the brushes may be kept when once adjusted. The holes *a a* are drilled ⅜ clearing, in order that a strip of 1/16 inch vulcanite fibre may be warmed and bent to form an insulating bush for the screwed end of the studs B, which are provided with vulcanite washers, *c c*, to complete the insulation of each stud. These studs are fitted with two hexagon nuts, *f*, one for tightening the stud upon the holder, and the other free for attaching the connecting wire, which should be turned and flattened.

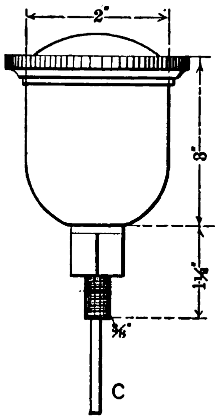
A small hole at *d* is drilled for the convenience of holding the stud by means of a "tommy," while the nut is tightened. Another hole at *g* is for the purpose of holding the end of the tension spring *e*. The brush box is shown at C, figure 11, and its shape and fitting need no explanation further than that *i* is drilled half clearing, to fit upon the studs B, and *h* is a small hole for receiving the other end of the spiral spring *e*. A small fly-screw, K, tightens the brush E, the plate D intervening, and rendering the pressure uniform over the brush.

The brushes may be made of No. 20 B.W.G. copper wire, cut off to length and straightened, then clamped in a box, leaving about ½ inch projecting, which may be cleaned in "dipping acid," and tinned by the method recommended for the commutator connectors.

These wire brushes should be about 3/16 inch thick, and a band should always be placed round the end to prevent the brush from straggling and doing mischief. Some electricians prefer brushes made of copper stencil plate, in successive layers, and such brushes certainly have one advantage over the wire ones, in that the surface of the commutator is kept much more true in running.

TERMINALS.

The terminals upon their plate of polished wood (A and B, figure 12) give quite a finished appearance to the dynamo, if they are well made. The holes and screws in the base of the terminals are for the purpose of coupling the brush connections, which should be of stout wire, bent symmetrically, and well taped. If the machine is to be shunt, or compound wound, a third hole and screw must be fitted on the base, and these may be smaller, because the wire held by them is invariably finer.



LUBRICATOR (2)

A dynamo fitted with a scanty pair of terminals always presents the appearance of scantiness, and the machine suffers in the estimation of every expert before they have an opportunity of judging by its efficiency.

The amateur has a wide field before him when selecting a lubricator; but for appearance and utility the style shown at C, figure 12, will probably suit his purpose best. The milled cover unscrews, of course, and the needle should fit well, and an oil that is too fluid should never be used, because the draught from the armature drives a spray in both directions if the flow be too free. Long bearings, like those desired for this amateur's dynamo, wear very slowly, despite the high speed, with just enough lubrication to maintain the film, and no dirt. A very slight "end play" should be allowed, say 1/16 inch; it allows the commutator to wear without ridging, and assists lubrication of the bearings, and keeping the armature cool, very materially.

WINDING THE FIELD.

The field-magnet casting must be put in the lathe, utilizing the centres before mentioned; then a good coat of shellac varnish should precede a layer of stout brown paper; then the ends of vulcanized fibre, which, being slit, may be sprung over the cores. These ends should be cut larger than the iron projections cast upon the magnets, so that the wire is never dangerously near the iron. Three thicknesses of 1/32 inch fibre for each end and one of brown paper; then the whole may be coated with shellac, and the core wound with two layers of unbleached calico, again varnished, and left to dry.

In the case of a series-wound machine a groove or chine should be chipped so as to allow the wire end to pass up the cheek of the pole-piece without distorting the coils, and a gutta-percha tube slipped over it. When winding a shunt machine, it is better to bring a thicker wire out for the connections, for there is no remedy for a broken wire but entire rewinding.

Having in this way prepared for the wire that is to be

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laid on, the next operation is to calculate how much and of what gauge it is to be, having already ascertained the required resistance by the methods previously explained.

In the construction of a dynamo, the field winding is the most difficult of all the calculations; the formulæ which apply to it are full of co-efficients, thus rendering them useless for amateurs; therefore, as the object of these papers is to simplify these calculations, even at the expense of the fractional part of volt or ampère, the rules given are simple, so that the amateur may work out his own winding for whatever purpose he intends his dynamo.

For elliptical cross sections of F.M. core, as in the present instance, *the depth of the coil of wire should be rather less than ¾ of the conjugate (or lesser) axis of the ellipse*, which may be represented by the multiplier 0.7. This applies to both shunt and series winding, for, as stated before, for coils of the same depth, but of varying resistances, the portion of the total electric energy used in magnetizing the cores is equal or nearly so.

The elliptical section of core here is—

Transverse axis = 3.25 inch. (I.)
Conjugate axis = 2.00 inch.

Then the area is $3.25 \times 2 \times .7854 = 5.1$ square inches, and the depth of wire $2 \times 0.7 = 1.4$ inch. Now, the weight of wire of any gauge that can be wound to the aforesaid depth, must be roughly ascertained before the right gauge can be chosen to suit the calculated resistance. A method described by Mr. J. T. Sprague ("Electricity: its Theory, Sources and Application") is here slightly modified to suit the present circumstances, as follows:—

Find the area, in square inches, of the ellipse formed by the wire when wound on to a depth of 1.4 inches.

Transverse axis 3.25 + (1.4 × by 2) = 6.3 inch. (II.)
Conjugate axis 2.00 + (1.4 × by 2) = 4.8 inch.

Then $6.3 \times 4.8 \times .7854 = 23.7$ square inches, from which must be deducted the area of the iron core $23.7 - 5.1 = 18.6$ square inches.

Then, multiplying by the length, 7 inches, we get the solid content of the wire coil in cubic inches, $18.6 \times 7 = 130.2$ cubic inches.

Now, to obtain this in pounds of copper wire, a multiplier must be taken which represents the weight of a cubic inch of copper in decimals of a pound, and at the same time allows for the cotton covering and the rotundity of the wire; these multipliers may be thus expressed—

From 6 B.W.G. to 10 B.W.G. = 0 21 (III.)
" 10 " " 14 " = 0.20
" 14 " " 16 " = 0.195
" 16 " " 20 " = 0.181
" 20 " " 22 " = 0.174

Now, suppose that the present dynamo is to be shunt-wound, and the resistance of the armature, its E.M.F., and the external resistance of the circuit are known, and the problem remains for solution—(1) the resistance of the shunt; (2) the weight and gauge of wire; (3) the work done in excitation.

We must assume that the E.M.F. is 60 volts, actual r_a of the armature 0.3 ohm, and external circuit r_1 is 4 ohms. Then by the formula, $r_1^2/r_a = r_s$. Substituting the known values, $4^2/0.3 = 16/0.3 = 53$ ohms.

Then, choosing a wire gauge between 16 B.W.G. and 20 B.W.G., where the constant is .181, the known solid content in inches of the coil must be multiplied by it, $130.2 \times .181 = 23.4$ lbs., and referring to the wire table (table III.) for ohms per pound, No. 18 B.W.G. will be found to suit the requirements, the resistance being 0.57 ohms per pound. $23.4 \times 0.57 = 13.3$ ohms, and since there are four coils, $13.3 \times 4 = 53.2$ ohms, which is the required r_s. If, on the contrary, we suppose the same dynamo to be series wound, the total resistance of the field r will be 0.24 ohm, and a wire must be selected to carry 15 ampères without heating, which must necessarily happen if the depth and resistance are not kept to their proper ratio. Now, choosing a wire from 6 B.W.G. to 10 B.W.G., we find the weight to be $130.2 \times 0.21 = 27.3$ lbs., and taking No. 6 B.W.G, where the resistance is .0021 ohm per pound, we obtain $27.3 \times .0021 = .057$ ohm, and for the 4 coils, $.057 \times 4 = .228$ ohm, which is near enough for all practical purposes. But such stout wire as No. 6 is extremely difficult to wind on account of its thickness, so a wire of less diameter may be chosen, and the field magnet circuit coupled with the right and left pair of coils in multiple arc, thus dividing the total resistance. For instance, take No. 10 B.W.G., where the resistance is .01 ohm per lb.—$27.3 \times .01 = .273$ ohm, the resistance of one coil, and $.273 \times 4/4 = .273$, the resistance of the two pairs in parallel, which is near enough.

Now, to ascertain the number of ampère turns in these examples, it is necessary to divide the depth of the coil by the diameter of the wire over the insulation; thus, in the shunt winding, the diameter of 18 B.W.G. is .056 inch, so that—$1.4/.056 = 25$ layers deep, and $7/.056 = 125$ layers in length, so that each coil has $125 \times 25 = 1,125$ turns.

The E.M.F. is 60 volts, and resistance of the shunt 53 ohms, so that the exciting current will be 1.1 ampère; therefore the number of ampère turns will be $1125 \times 1.1 = 1237.5$ ampère turns. Now, comparing this with the last example of series winding—viz., No. 6 B.W.G.—and the diameter of No. 6 being .22 inch, $1.4/.22 = 6$ layers deep; $7/.22 = 31$ layers in length; $31 \times 6 = 186$ turns per coil. Then, with armature resistance .3 added to the magnet coil resistance .22, and external circuit 4 ohms, makes a total resistance of 462 ohms. Now, $60/4.52 = 13$ ampères, and $186 \times 13 = 2,418$ ampère turns per coil.

WIRE TABLE.—III.

Number.	Inch diameter over insulation.	Yards per pound.	Yards per ohm.	Ohms per pound.	Pounds per ohm.	Safe current.	Multiplier per cubic inch.
6	.221	2.67	1330	.0021	497.4	60	
7	.213	3 39	1046	.0032	307.8	48	
8	.182	4.04	879	.0046	217.3	43	0.21
9	.166	5.02	707	.0051	140.6	36	
10	.150	6.13	580	.0105	94.5	28	
11	.135	7.64	465	.0165	60.8	21	
12	.122	9.26	383	.0241	41.3	18	0.20
13	.119	12.2	291	.0418	33.8	13	
14	.098	15.9	222	.0718	13.9	10	
15	.085	22.3	158.3	.1424	7.0	8.5	0.195
16	.076	26.0	136	.1918	5.23	6	
17	.068	32.7	108	.3013	3.31	5	
18	.059	45.8	77	.5715	1.69	3	.181
19	.050	62.4	57	1.095	0.92	2.5	
20	.043	89.8	50	2.273	0.44	2	
22	.033	140.4	25	5.549	0.18	1.5	.174

All these calculations will serve the purpose of the amateur, and assist him to determine the gauge, weight, etc., of wire to produce a certain result; but, as all the resistances are taken from table, and considering that the wire manufactured by different makers varies considerably, it will be well for him to procure a table from the particular maker who supplies him with material. He may also test the resistance per foot, yard or pound with a Wheatstone bridge.

Another method of increasing resistance is to pass a current of known quantity through the wire, and test the potential at terminals, when $\frac{E}{C} = R$; but this necessitates the use of a good voltmeter and ammeter. However, by the simple rules given here, the amateur may calculate his winding so as to get the required result with the least *effective* weight. The first step in obtaining the depth of the coil forms a basis to work upon, and is not intended for the purpose of founding a new theory of winding dynamos, and the general rules given here have been the result of experiment and practice.

Presuming that the wire has been chosen and obtained, and is double cotton-covered and of good quality, we may proceed with the winding. The wire should be placed upon a drum or spool, which may be braked, so that it does

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not revolve too freely and so get the wire tangled. The winder will again stand behind the lathe, unless he reverses the motion by crossing the belt. He will guide the wire while the lathe goes at a steady speed, and his assistant will tap the wire flat and even with a mallet and wooden wedge. Each layer should receive a coat of varnish or Brunswick black.

The winding should *commence* on each coil close to the pole-piece, and a length of stout wire, say No. 14 B.W.G., if the machine be shunt wound, or No. 7, should be soldered to the starting end, well-taped, insulated with tube inside the coil, and then placed within the groove cut in the iron for it. Then the winding may go on, always finishing at the *under* side of the upper magnet, at the farthest end from the poles. The other magnet is commenced in the same place—viz., nearest the pole, but finished off on its upper side, opposite the pole. With this method of ending and finishing the coupling up is easy. Suppose that the dynamo is fitted up, then couple the *commencement* of the top left-hand coil to the nearest terminal, then the *termination* of No. 1 coil to the *termination* of lower left-hand coil No. 2. Then bring the *commencement* of No. 2 across to the *commencement* of the lower right-hand coil, No. 3, the *termination* of which couple to the *termination* of No. 4, the *commencement* of which couple to the other terminal if a "shunt" machine, and if wound in "series," of course, one end will be attached to one brush-holder, while the other will be coupled to the opposite terminal.

The winding of the field-magnets should be carefully performed, or the effect of the machine may be marred. Nothing looks worse or more unworkmanlike than a bad and irregularly wound coil. When wound and coupled up the field-magnets must be tested for polarity, which is done by means of an ordinary shilling compass, taking each half of the field at once, right and left, not top and bottom. Taking top commencing wire, say mentally, "*enter*," then take the *commencing* wire of the bottom coil, and say "*leave*," and couple one to carbon and the other to zinc of the battery, taking care to note which is which, since where you have disconnected the two right and left halves at the bottom, the *leave* wire of the one will be the *enter* wire of the other half to produce the same polarity.

Having tested the polarity, the whole dynamo may be touched up and nicely painted, and placed on the foundation that may have already been prepared, and the belt adjusted to the proper degree of tightness, and the power applied. If the dynamo be shunt-wound, the magnetism of the field will commence immediately; but if, on the contrary, it be a series-wound machine, the external circuits must be closed before the magnets can be acted upon.

If a voltmeter and ammeter are to be borrowed or hired, get them ready for testing away from the influence of the magnets as far as possible; then test your machine for E.M.F. (if shunt-wound) with the circuit open and current passing round the shunt coils; then $E/C = R$ in ohms of shunt. Test speed. Then put the full load of lamps on the machine, put the ammeter in circuit, and test current strength and E.M.F. in volts at the terminals again. The difference in E.M.F. represents that factor of the energy which is absorbed by the machine itself.

Now vary the load, and notice the behavior of the machine, whether an alteration of the angle of the brushes is an improvement or a decided disadvantage. Test the speed again, which should be tolerably constant if the motive power be suitable for the work. If the speed falls when the load is on, the loss of E.M.F. will be attributable to the driving power, and not the dynamo.

Every part of the frame of the machine should be tested for leakage; but since such leakage may result from defective insulation in the external circuit, they should be tested separately, allowing the current from the machine to pass through a temporary resistance during the test.

The brush-holder should be brushed carefully all over each day to prevent the metal dust from the commutator from bridging across the insulating washers and causing leakage.

No dynamo, whether it be shunt or series wound, ought ever to be short circuited; but in the latter case the danger of total destruction is greater; therefore, it is a good plan to introduce a "cut-out" in the F.M. circuit, which will melt and open the circuit if the current be excessive. A strip of lead, clamped between two sets of brass bars, which are connected to the wires, will suffice The commutator must never be "oiled"—a touch with an oily rag being sufficient lubrication.

MODIFIED FORM OF WHEATSTONE'S RHEOSTAT.

A WIRE is coiled upon a non-conducting cylinder as in the ordinary forms of rheostat, one end of the wire being in contact with the brass axle of the cylinder. A screw is cut upon the axle, the pitch being equal to the distance between the consecutive turns of the wire, and this, working in a fixed nut, causes the whole cylinder to travel in the direction of its axis. A fixed spring bears upon the wire at a convenient point, and, by the traveling motion of the cylinder, this point of contact remains fixed in space, and the effect of turning the cylinder is to introduce more or less resistance between the spring and the brass axle. Binding screws on the base of the instrument are in contact with the nut and the bearing spring. Though this arrangement has several obvious advantages over the usual forms, Mr. Bidwell does not recommend it in cases where it is required to introduce a known resistance; but where it is important to adjust a resistance to a nicety or to cause a continuous variation, it is of great use.

Professor Perry, remarking upon the importance of being able to vary a resistance gradually, described an instrument he had used with advantage. A number of plates of gas-carbon are placed between two parallel copper plates, one of which is fixed and the other adjustable by a screw; by applying pressure by means of the screw, the resistance between the plates can be varied uniformly and regularly from two to ten ohms, beyond which point the increase is very rapid.—*Shelford Bidwell, in Physical Society.*

BICHROMATE OF SODA.

IN the manufacture of this product, the neutral chromate of soda (Na_2CrO_4) is first obtained by heating in a reverberatory furnace six parts chrome iron ore with three parts soda ash and three parts chalk. The mass is thrown in water while still hot, and the lye thus produced is evaporated to 112° Tw. in iron vessels, and then poured in leaden vessels to crystallize. A product is obtained of the formula $Na_2CrO_4+10H_2O$, which, if dried in a stove at about 30° C., loses all its water of crystallization, and gives a Canary yellow powder.

The bichromate is obtained from this neutral chromate by dissolving in hot water, and then add sufficient sulphuric acid to convert it into the bichromate, which is seen by means of iodide starch paste, which is turned brown at the end of the reaction; then enough neutral chromate is added to the solution so as to obtain a product containing 72 per cent. chromic acid. After cooling, when the sulphate of soda crystallizes out, the liquor is removed and evaporated to dryness in iron boilers by constant agitation. The ultimate product, which is a mixture of the bichromate with the neutral salt, is less hygroscopic than the pure bichromate, which is thus obtained in the form of egg sized lumps, which, being ground, forms then the commercial article. It is interesting to note that the bichromate of potash is less poisonous than the sodium salt. The commercial bichromate of soda contains about 72 per cent. chromic acid.—*N. Walberg, in Dingler's Polyt. Journal.*

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THE GENESIS OF INVENTION.[1]

BY FRANKLIN A. SEELY, A. M.

Examiner in the U. S. Patent Office.

DURING the past few years unusual attention has been directed to the study of human inventions. The close relation between the amelioration of man's condition and the improvement of his mechanic arts have led to the consideration of the subject as one in which social science is concerned. It has been observed that institutions of every character—languages, laws, customs, philosophies, and beliefs—have been largely, if not wholly, the product of invention of somewhat the same character as that which has produced tools and machines. The term invention has acquired a broader scope, and includes every subject on which human thought and ingenuity and fancy may exercise themselves. Its study is therefore of no little consequence. It is no longer limited to the field of mere mechanics and physics, but embraces all that concerns whatever has been devised by men to satisfy the material and moral needs, either of the individual or of the mass in their various social relations. I propose to inquire what are the processes by which inventions are produced ; what influences lead to them ; what laws, if any, they follow ; and what results, immediate and ultimate, flow from them. I conceive that these inquiries are best pursued in connection with mechanical inventions. A parallel inquiry might be pursued in respect to inventions in the broader sense. In fact the study of savage society is, to a certain extent, such an inquiry.

Before proceeding to the consideration of the subject, it is important to call attention to the various meanings and shades of meaning of the word *invention*, which we have such constant occasion to employ. A late writer on patent law[2] refers to this in his opening chapter as a source of much confusion, since, as he remarks, it is not uncommon to find the word used in different senses in the same paragraph, even in the same sentence. He distinguishes four meanings of the word :

(1) The mental act of inventing.
(2) The thing invented.
(3) The fact that an invention has been made.
(4) The faculty or quality of invention.

It is scarcely necessary to illustrate these significations, since on a little reflection they become apparent. We may say of the sewing machine, *it was the invention of Howe*, referring to the mental process which produced it ; we may say it *is a great or useful invention*, meaning the machine itself ; we may say *the invention of it revolutionized the manufacture of clothing*, in which we mean the fact that it was made ; and we may say of any particular form presented to us, *there is no invention in it over some earlier form*, in which we refer to the quality of invention as distinguished alike from the mental act, the concrete product, and the historical fact. In view of all these uses of the word and not to overload it further, I shall venture to suggest a new one to designate the study of invention. This study has not yet perhaps developed itself as a true science, though it appears to possess all the elements of a science. As a study of growing interest it is worthy of a name of its own, and, with all deference, I submit to the Society, as an appropriate name worthy of adoption the word *eurematics*.[3] This should include the study not of arts, machines, laws or institutions in themselves, but of them all in respect to their methods of growth and the means by which they have been developed and are still developing. This is a study which many are pursuing with eagerness and delight ; and the need of a name for it clearly separating it from other kindred studies is every day more apparent.

It is my purpose to present in this paper a brief chapter in this science, following out and perhaps, to some extent, repeating some of the thoughts expressed in a paper presented to the Society two year ago,[4] in which I discussed the nature of the earliest human inventions, the original germs out of which they grew, and the steps and processes by which they were evolved or elaborated. Speculative as some of my suggestions may have been as to the nature of these primitive inventions, nevertheless the nature of the processes by which they were made is so inherent in all arts that it cannot be regarded as in any degree speculative. Possibly the inventions pointed out were not actually the first contrived by man, but whatever were the first, the way described is beyond doubt the way in which they were arrived at.

I propose in the course of this paper to discuss the development of the stone hatchet in its most finished form ; but before doing so it is necessary to inquire into the nature of invention and some of the general principles it follows. Lying absolutely at the bottom of such principles are the following postulates, the A B C of eurematics : Given any artificial implement or product, we must assume—1st, *that there was a time when it did not exist ;* 2d, *that before it existed there must have been a creature capable of producing it* ; and 3d, *that such creature before producing it must have been conscious of needing it, or must have had use for it.*

There can be no orderly discussion of the genesis of any art without recognizing the truth of these postulates at every step. Questions may arise upon resultant or collateral propositions, but, admitting all that can possibly be claimed for accident as an element in invention, these propositions are not to be questioned. They are fundamental, and no logical consequences that flow from them can be evaded.

The first proposition, that before any artificial product existed there was a time when it did not exist, is not startling, and may be passed over for the second ; before it existed there was a creature capable of producing it. This is as much as saying that no product of art came into existence simultaneously with its producer, and seems to be no more startling a proposition than the first ; and yet, if I rightly interpret the ideas of most writers, they have failed to grasp even so common-place a truth.

The third proposition, that the producer must have been conscious of needing the product, or must have had use for it before producing it, is not at first sight so obvious. In fact I believe the failure to grasp this truth is a great source of error and misconception among many writers. No one, however, who has given any thought to the nature of invention, has failed to observe that every step in the mechanic arts has grown out of a pre-existing want. Not necessarily out of a pressing need. Invention now-a-days does not wait for the call to be so urgent that waiting can be no longer. Long before this stage necessities are anticipated, and the means by which they are overcome often do not become indispensable till the very habits they engender make them so. Illustrations of this are all around us. The sewing machine, the reaper, the telephone—what could we do without them? And yet in our own generation we have done without them all. They have themselves created the conditions which have made them indispensable. But none of them came by accident. They have been, every one, the fruit of years of toil and thought and anxiety on the part of those who saw, what few clearly comprehended, the imperfection of the means employed to do the daily work of mankind, and studied to produce better means. This is the history of steam, of electricity, of railroads, of metal working, of pottery, of every art that has a recorded history. Prevision and calculation are so truly elements in the growth of all known arts that in asserting their universality we incur no more risk than did Newton in asserting the law of gravitation.

1. Read before the Anthropological Society of Washington, May 5, 1885.

2. Merwin. Patentability of Inventions. Boston. 1883

3. *Εὕρημα*, an Invention. If the Greeks had been in the habit of philosophizing about inventions, they would have had an adjective, *ἑυρημάτικος*, and the word would have found its place in English long ago, as has *eureka*,

4. An Inquiry into the Origin of Invention. Vol. ii, Trans. Anthrop. Soc., Washington. 1883.

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What then, it may be asked, is the place due to accident in invention? Notwithstanding a popular belief that many if not most of the great inventions have been the fruit of accident, it may be asserted that the contrary is true. Fortuitous circumstances, trifling unforeseen incidents, have in many cases doubtless suggested expedients which have led to the consummation of great inventions. It was an accident—the result of his poverty—which led Senefelder to write on a stone slab his family wash-bill, and so led to the invention of the lithographic process; but the accident did not occur, and could not, till long and persevering pursuit of a method of printing cheap music had brought together the polished stone, the ink, the acid—all the materials necessary to accomplish the result. Possibly it was an accident which led Goodyear to the use of sulphur for the vulcanization of india-rubber; but the accident, if such it were, did not occur till years of expense and toil and experiment with a great variety of materials had led the way to it. And the rubber and the sulphur and all the appliances necessary for the experiment were ready to his hand, all accumulated in the pursuit of his lifelong purpose. Such experiences are common, and familiar illustrations of them are found, as for instance, in the lives of Palissy, the Huguenot potter, and William Lee, the inventor of the stocking loom. In these the element of accident enters in some degree into the consummation of the invention; but in every case it is such accident as might have occurred a thousand times over without result to other men whose minds were not intent upon the invention. Lamps had swung for centuries in the Italian cathedrals, and men had idly counted their oscillations as they kept time to the tedious delivery of generations of dull sermons; but the isochronism of their swing if observed at all, was not regarded till Galileo came.

The true and only field that philosophy can concede to accident in invention is that it supplements and sometimes abridges the labor, calculation, and time of the inventor. To a man filled with a steadfast purpose, all his senses alert to every means chance or calculation may present to accomplish it, the most trifling incident may furnish the clue, which has fled from him like an *ignis fatuus*. To another the same chances may come and go continually without result. And while it cannot be said that accident has no place in invention, it must be conceded that its place is completely subordinate to other elements. Great inventions have been the fruit of accident in the same sense and to the same degree that a ripened peach is the fruit of the rude blast that shakes it from the bough.

It is important in a discussion like this to keep clearly in mind the difference between invention proper and discovery. The function of the latter is to bring to light the material facts, and the natural laws, which the former applies to useful purposes; and in respect to discovery, the element of chance, of accident, is important. The progress of scientific discovery is marked at every milestone by the revelations of accidents, which the thoughtful mind of the inventor did not apply to practical ends till long afterwards, when the need had arisen. If it was an accident that led Galileo to the discovery of the isochronous oscillation of the pendulum, it was not till fifty years afterwards that this discovery was applied to regulate the movement of a clock. The phenomena of electricity that accident may have revealed to Galvani and Volta, are the basis of inventions that the most active minds of this decade are expending their best energies upon. It cannot be denied that in discovery accident has played an important part; but the more this fact is considered, and the more we consider the true function of discovery, the more strongly do we find the proposition confirmed that improvements in the arts are not the result of chance but of intelligent efforts to supply conscious needs. Hence I shall regard this proposition as conceded, and I pass to another.

(4) *Every human invention has sprung from some prior invention or from some prior known expedient.* Inventions do not, like their protectress, Pallas Athéne, spring forth full grown from the heads of their authors. This suggestion needs no argument when made regarding any of the modern inventions. Every one of them is seen by the most superficial observer to be built upon or elaborated out of inventions and expedients previously in use. It is only when we go back of these and study the expedients and appliances out of which they have grown, and whose history is unrecorded, that the proposition I contend for is not obvious. And yet there is not a single one of them which does not when studied exhibit in itself the evidences of a similar substructure. In the process of elimination we go back and back, and find no resting place till we reach the rude set of expedients, the original endowment of men and brutes alike. This is a truth which study more and more confirms, and from it the proposition stated may be deduced as one of the laws of invention.

It may be deduced as a corollary to this proposition, but at the same time a fact determinable by independent observation, that the generation of one invention from another is not immediate but always through one or more intermediate steps. The effect of every invention fundamental in its character is first to generate wants before unknown or unfelt. The effort to supply these wants leads to new inventions.[5] These may be quite distinct in their character from the original invention in which they indirectly owe their origin. They are related to it only as means to supply some want to which it has given birth. I shall not pursue this branch of the subject. Illustrations will occur to all. There is hardly a branch of industry that has not felt the effect of inventions based upon wants created by the introduction of petroleum, or the general use of the telephone. Wood-working, mining, transportation by land and sea—all the avocations of men—have felt their influence, have found wants engendered by their use, and improvements have been made to meet these wants. The wants of primitive man were limited, and his inventions were accordingly few. As wants increased in number and intensity, inventions multiplied, and the numberless wants of modern civilized life are only paralleled by its numberless arts and expedients.

I set it down as a fifth proposition: *Inventions always generate wants, and these wants generate other inventions.*

A sixth proposition is that the *invention of tools and implements proceeds by specialization.* This is true to a certain extent of all arts, though perhaps not a universal truth regarding all invention. It results, as will be apparent on reflection, from the last proposition. A single tool may have a great variety of uses, but, if there is a sufficient requirement, men will not long be contented with one tool for those uses for which it is least convenient. It will be reserved for that to which it is best adapted, and other forms will be devised better suited for special uses; possibly the parent type may be found inferior for all uses to some of its modified forms, and it may, on the principle of the survival of the fittest, become obsolete. Look at the variety of tools on a joiner's bench, chisels, planes, saws, each especially adapted for its particular work, but all pointing back to a time when there was but one form of chisel, or plane, or saw. The "jack-plane" and "long-jointer" may each be made to perform the work of the other, but they do it very imperfectly. The primitive bench plane was like neither, but was the type of both. There is nothing more striking than the variety of cutlery on a well-furnished table. The time is not remote when one knife worn at the belt served the purpose of all these, so far as these purposes existed, and of many others; when the table knife was not differentiated from the dagger of the soldier or the tool of the artisan. A man then used

5. A curious instance of this is brought to my attention while writing this paper. In consequence of the expiration of the earlier patents on roller-skates, a great impetus has been given to their manufacture, the result being the exhaustion of the world's stock of boxwood of certain sizes used for rollers. And to supply the want so created hundreds of people are trying to invent a suitable and cheap substitute for boxwood for this purpose.

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one knife to cut out a leather sole, to shape his arrow, to carve his food, and to stab his enemy. Changes in modes of living have led first to the broader specializations; fashion, caprice, and increasing refinement to others; till one scarcely dares attempt to enumerate the various forms of carvers and table knives of various sorts differing in form and material, each adapted by some feature for its particular use, and each the result of some degree of invention, with which the tables of Europe and America are furnished. Undoubtedly this process has gone on ever since man became an inventor, and might be illustrated as perfectly, though not so profusely, in the implements and weapons of the savage as in those of civilized men. All study of invention must take account of it. As soon as men began to adapt sticks to their use by artificially pointing them they began to find in them various degrees of hardness, weight, length, and rigidity, qualities fitting them for diverse uses, and as skill and experience were acquired they fashioned them accordingly. Likewise when man had begun to employ flint flakes, and before he had learned to fashion them to his will, he selected from the splinters made by accident or by his own unskilled blows those which served best such diversified uses as he had found out.

My seventh proposition, and final one so far as this paper is concerned, is that *no art makes progress alone.* I venture to assert the universality of this truth from what is seen in the recorded history of all inventions. In the development of the mechanic arts, two or more arts distinct in their nature but having close interdependence make advance *pari passu.* If one lags the other is necessarily retarded. If one makes rapid progress the other springs forward with quickened impulses. An improved utensil or article of manufacture may be the result of or may lead to improved processes and tools and machines for producing it, or to improved means for its employment. The progress of the steam engine was long retarded by the imperfection of iron-working machines, since perfect cylinders could not be produced. The progress of electrical invention has necessitated the invention of new machines and processes for insulating wire. The introduction of illuminating gas has created a demand for metal tubing, and machines for its rapid and perfect manufacture. And so every step in every art is marked by one or more corresponding steps in other arts.

These general principles, imperfectly stated as they are, by no means exhaust the study of invention. They only lie at its threshold. They are among the more obvious laws which inventions follow as they are every day presented to the mind of those who deal with them: so obvious, that I have found myself hesitating as to the value of their presentation in this form; a hesitation which is removed by observing that, so far as writers upon early inventions are concerned, they are unnoticed and apparently unknown. Further chapters in eurematics might be devoted to the elucidation of other truths equally generic and universal, but more intricate and therefore less obvious. I might cite for instance the tendency of civilization to convert luxuries into necessaries, true not only of absolute civilization but of every stage of it or every step towards it. The effect of this tendency upon inventions is marked and positive. I might cite the fact that invention is stimulated by rewards and retarded by opposition, which history abundantly illustrates—eminently the histories of France in the middle ages, of The Netherlands, of Great Britain, and of our own country. Another proposition might be that the truth regarding biologic evolution—that the type of any species which is to predominate is at its first appearance unconspicuous—applies equally to the evolution of arts. Many such propositions more or less recondite might be stated, the adequate discussion of which would require a volume; but I can afford to pass them by, as I have not set out upon an exhaustive study. The few propositions considered are enough for the present purpose.

I shall now discuss the progress of invention in a single direction, partly as a study in itself, partly by way of illustration of the doctrines I have enunciated. I have selected the stone hatchet for this purpose, because in some of its ruder forms it represents the earliest human workmanship of which any knowledge has come to us, and also because in its rudest form it presents the evidences of being the fruit of long antecedent growth. Further than this I observe that primitive as it indeed is, and in its highest development rude and ineffective in comparison with the finished implement of this age of steel, the thoughtful student of invention sees in it the culmination for the time being of human art rather than the beginning. For the purposes of this paper I regard nothing less than the hafted celt as the finished implement whose genesis I shall attempt to indicate.

I assume as the starting point the conclusion reached in my paper before referred to,[6] that the earliest mechanical process employed by man was the art of working wood by abrasion. This cannot be regarded as proven; absolutely proven it can never be; but it comes in as a link connecting what must have been in the history of primitive man with what is revealed to us regarding the man of the earliest stone age. This art, or something closely similar to it, appears as the immediate derivative of the original mechanical expedients of man in a state of nature, and of the wants engendered by his human characteristics. Tracing back the art of wood working we find no resting place till we come to the art in this condition. In short the more the subject is contemplated, and from whatever point of view, the stronger appear the probabilities, so strong that to my mind they are convincing. Starting from this basis, what was the process, what the result sought, what the methods employed to produce it?

The object sought for was a pike, a strong, rigid, sharp-pointed stick or shaft adapted for use as an offensive and defensive weapon, a want early felt and hitherto imperfectly supplied by chance and nature. The means employed was a rough rock, a coarse sand-stone or mill-stone-grit upon whose exposed surface the wood was rubbed or drawn back and forth until reduced as desired. A tedious process, but not more so than many of those employed to this day in the arts of savage life. We can imagine men coming from great distances to the inventor of this art with poles on their shoulders to be prepared in the new style. It would not at once be perceived that no special properties attached to this particular rock, that rocks having similar properties and perhaps better suited to the purpose were every where. The mind was dull in grasping the essential fact of the art, and perhaps for ages superstition and fetichism may have been engendered by this very improvement. It is easy to see, however, that it had created a new want, or perhaps intensified the old one. Pikes were liable to be broken, were subject to natural decay. They must be replaced, and new ones were always in demand. Their artificial production had increased the number of their possessors, and the want of a ready means for the replacement was more widely felt. To the majority it was a new want. Hence among people widely scattered, more convenient and accessible means were sought for supplying the demand; and in answer to this want came the discovery, perhaps the result of similar experiences and observations, that gritty rocks every where would yield the same results to similar manipulation by the hands of any one. And a further discovery followed close on the heels of this, that the jagged edges of flints and other hard rocks would by a manipulation but little varied perform the work better and faster than the gritty surface of the sand stones. A stick drawn forcibly over such a sharp edge has its surface scraped from it in thin shavings instead of being merely abraded as heretofore. This important step from abrasion to scraping, which is in

6. An Inquiry into the Origin of Invention. Vol. II. Trans. Anthrop. Soc. Washington. 1883.

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fact cutting, was therefore reached before any cutting or abrading tool had been devised. Reached by slow steps, in answer to a felt want, but a want in no way pointing to it, it was actually the invention of another and quite distinct mechanical process. It was a better process, gave better results, and the weapon and the art of wood working made progress together.

We have advanced one step, man now has the notion of the cutting edge and its use. But it is part of an immovable boulder or ledge, not always accessible, and the want of a convenient means always at hand is but partially supplied. The long pilgrimages which had to be taken to the primitive pointer of pikes were at an end, but the journeys though shorter still have to be made. How was the next step, resulting in the production of a portable cutting implement, to be accomplished?

It will be seen at once that in the use for a considerable period of the edge of a rock for cutting purposes it will become dulled. Other parts of the rock having exposed edges will be sought, and these will become dull in turn. This dulling process proceeds more or less rapidly according to the material applied to it; and as the harder woods were found to be in all respects more serviceable they were more generally used. We may conceive that at some time by the violent application of a hard piece of timber to an edge somewhat thinner than ordinary, the edge itself instead of being merely dulled is broken off, and to the pleasant surprise of the operator a new edge, sharp and clear, and better than the half-dulled one he had been using, makes its appearance. And he eventually learns that he can at any time produce a new edge by shivering off a piece of the rock with blows. He is not long in learning that the part broken off has similar edges. If it be large enough to lie firmly he can employ it as he does the parent rock. If smaller, he may hold it firmly with his feet while he manipulates the wood upon it with his hands. Perhaps he can carry it away and use it at the place most convenient to him; when dulled he can shiver it by a blow or two and it is sharp again. And then at last by slow degrees, requiring ages perhaps, one can hardly tell how, but by the continuance of this process, he observes that these splinters struck from the fragment, these fragments of fragments, possess the same cutting edges as the original rock, and in a bit of stone not larger than his hand or his finger he possesses an instrumentality capable of doing all that he and his ancestors have been laboriously doing on the parent rock or clumsy fragment. He learns also that instead of dragging the wood over the edge, he can, with a totally different manipulation, hold the wood firmly and operate on it with the stone splinter, and the tool is invented.[7]

When I think of man in his primitive condition, as the logical necessities of this subject have compelled me to think of him, helpless, miserable, the prey of beasts, without tools, without means of defense except such as he shared with the beasts, and then think of him in the condition to which he is brought in this outline of his inventions, I find it impossible to adequately express my sense of the progress he has made. One effective weapon, its structure improved, and skill in its use acquired by generations of experience, and one cutting tool, even in the rudimentary form of an unfashioned flake, have separated him incalculably from the condition of his ancestors. His knife or hatchet, as we may henceforth call it, contained within it all the possibilities of the future, but for the present—his present—its capabilities were learned by constant lessons and with every new occasion. He had no want to which it did not minister. It not only served its first purpose to prepare his weapon, but it became itself a weapon. It served him to procure and prepare his food, both animal and vegetable, his shelter, his raiment, if he had reached the stage of wanting raiment. Its acquisition was the greatest step he had taken in invention; and when we regard what has grown out of it, the infinite variety of cutting tools, implements, and machines, whose origin we remotely trace to it, and the unnumbered needs they supply, we cannot hesitate to ascribe to it the highest place among all the inventions of all time.

If the hafted celt was for the time the culmination of art, this is not less true, of its time, of the flint knife. As in man's rudest estate he used the expedients with which nature endowed him, selecting those best adapted to his immediate purpose, so now out of the diverse forms assumed by flakes and chips, he selects those best adapted for particular purposes. He is repeating what occurred in his earliest period, but with new and diversified wants, wider intelligence, and a greater range of material out of which to select. He finds blunt edges give satisfactory results in the old process of scraping wood, but he finds that thinner and sharper edges penetrate the wood deeper, and remove the superfluous material faster. He finds he can work more deftly, more conveniently, can put a finer point on his weapon, can apply the new tool to all parts of it, can reduce and trim the shaft as well as the point, can even sever the growing saplings to obtain his material. He finds that some forms can be made to penetrate and divide the tough skins of beasts, and carve their flesh. In fact, in whatever direction his necessities or inclinations lead him, he finds his knife in some form contributing to his comfort, his protection, and the supply of his wants. The possession of the tool has wrought out his mastery over nature.

This culmination in invention is but momentary. It is a mile-stone, a breathing place in the history of arts. But the march still goes on, and we find man still searching among fragments for forms adapted to his particular uses, but gradually learning by experience that by well-directed blows he can sometimes produce chips having special forms, and so fitted for special uses. But these are chips and flakes only. There is no attempt as yet at dressing or shaping stone. The rude forms they bear when shivered from the rock, are all that man has yet conceived in the structure of a stone implement. These rude forms seldom appear in our museums. They are the scoff of archæologists. They are not distinguishable from the work of the elements. In fact, the splinters thrown off by frost or fire may have been as readily selected for use as those formed by human agency. And as writers have agreed upon the name *palæolithic* to indicate the age marked by the first traces of human workmanship in stone implements, we must recognize the *protolithic* age, in which stone fragments showing no trace of such workmanship were the common implements of mankind. The earliest age of wrought implements could never have come but for such a precursor. The rudest wrought forms did not appear till something of the same nature and used for the same purposes, but imperfectly adapted for their performance, had created the need of them and led up to the means for its supply, and the one thing which bore these relations to the earliest recognizable forms of dressed stone implements was the unformed flake.

What were the steps from this form of flint knife, or scraper, or hatchet, to the hafted celt?

I formerly reached the conclusion that the original endowment of man could include no less than the stick and stone for striking and hurling, and the string or withe for tying or binding. In the course of this paper I have traced the synchronous development of the art of dressing wood, and of stone appliances for the purpose. With the advancement of these it is not to be supposed any former art or expedient was lost. On the contrary it is to be presumed that progress in them had been made corresponding to that we have been following. The club was better fashioned; approved forms of hurling-sticks may have been dis-

7. It is only by a loose construction of language that this can be called the invention of a tool. The tool, a mere flake of stone, had already long existed. The actual invention was an art or process quite distinct from any heretofore employed. The brief and more popular form of expression may be employed with this explanation.

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covered and come into use. Greater skill may have been acquired in the use of the hammer-stone, and judgment in the selection of suitable forms, either for crushing, or for splitting, and with more convenient hand-grasp. The flexible vines and strips of bark, with which primitive man lashed his frail shelter, his successor may have improved by rudely twisting the fibres or strands, or have supplemented by other materials, notably, after he had acquired the use of the flint knife, by strips of skin and animal tendons. The inventory of his possessions then would embrace the club and pike, each clearly specialized, the hammer-stone, not formed by art but selected, the stone knife, and strings of various materials. The pike, the hammer-stone and knife may have been of many forms. Now it will be seen that these elements may be brought together in various ways so as to accomplish a variety of results, the elements in every case being a stick, a stone, and a string to bind them together, and the difference in result depending on the particular form of stick and stone. For instance the heavy end of a club is made heavier by lashing to it a hammer-stone—result the mace. The pike is improved by securing to it a pointed flake of flint. A flint flake too small for the hand is made effective by fixing it to a piece of wood, making a knife or dagger. A heavier sharp-edged fragment secured to a handle adapting it for striking, becomes the axe or hatchet. What immediate incidents or needs led to any of these combinations, I do not propose to guess. It is enough to have shown that at a period when man was as yet unlearned in respect to any dressing of stone beyond knocking off rude splinters from a rock, he may have had in his possession the means to produce, and was fully capable of producing, such implements and weapons as I have named. This being true, the same wants which might at any period of his history have led to their production may without violence be presumed to have done so then. They are in the line of his acquired arts, and the necessary links between these and the arts he is yet to acquire.

Whether these various combinations were made prior to actual working of flint it would be idle to speculate. It is more likely that neither preceded the other. While man was finding out how to use his possessions by bringing them together in new combinations, he was naturally improving them all. Having found the flint and other rocks of similar texture so far obedient to his power that they could be shattered, and new and useful forms produced, having acquired uses for these forms, having learned the purposes to which a sharp edge could be applied, and that a fresh one could be produced by knocking off the dulled one—it followed in due course, from experience, to form the new edge with less violent blows, with more judgment and dexterity, and, as the advantage of special forms became apparent, with a view to bringing it as close as possible to such forms. And all this time the old art of reducing by abrasion had not been lost; applying it now to the stone as finer and finer chipping suggested and provoked the desire for a smoother edge, the celt appeared, polished at first on its edge only, afterwards on its entire surface. There was no dividing line between the palæolithic and neolithic ages. If separated at all, it is by a broad zone through which the implements of both are found side by side. Neither was there any step from the finished celt to the hafted implement. The essential step, that of securing a stone in some form to a handle, had been taken long ago.

Lest it might be suggested that in order to sustain a theory regarding the development of the arts, I have myself been led to invent steps in art that were never known to man, it is worth while to remark that none of the steps I have set forth are imaginary. All of them are in existence and in use yet, in their appropriate places, often amidst the completest appliances of modern mechanic arts. If the primitive man sharpened a stick by rubbing it over a rough grit, he used the same means an artist employs to-day to produce a fine point on his pencil, and the same by which we sharpen all cutting tools. The scraping tool is one of the ordinary provisions of a joiner's outfit; but the use of a bit of broken glass is more common still. As the edge becomes dulled by use, the glass is simply broken and two fresh edges are formed. This is universal in civilized life, and a curious instance of it in savage life has just been brought to light by the Rev. Lorimer Fison, in his pamphlet on the Nanga or Sacred Stone Inclosure of Fiji, in which he relates often having seen "a mother shaving her child's head with a bit of glass, and biting a new edge on the instrument when it became dull." These original arts have never been lost. Probably it is a general truth regarding mechanic arts that no one of them once commonly acquired is ever again lost. It may be laid aside for a time or suspended, but it revives in some form; and I venture to think that much of the eloquence that has been expended upon the "The Lost Arts" has resulted from a very imperfect acquaintance with those that exist.

It is apparent that every step in the progress that has been recited resulted in an improvement in man's condition. The first improved weapon, club or pike or missile, was equivalent to so much greater strength of arm or length of reach. It augmented man's superiority over the brutes; it made his life less precarious; it put the means of securing food, shelter, and covering more fully within his power. His environments, to which he had in his primitive condition been completely subject, he now could to a certain extent control, could subject to himself. The first improved means of fabricating a weapon, the first tool or mechanical process, accompanied these results in an increased ratio. The step that made the cutting tool the possible possession of every man, which made the knife even in its clumsiest form a common tool, did for the whole race what the earliest steps did for a limited number, and made this amelioration general. The increased number of forms and varieties of tools and weapons, growing out of the diverse and manifold wants they were adapted to supply, were each steps in the betterment of his material condition, each an indication of progress; man's advance towards civilization, slow as it must have been, was marked off step by step by the advances he made in his mechanic arts. The more he became independent of nature and capable of forcing her into his service the more time and inclination he found for the perfecting of his implements; and the more he perfected his implements the more capable he became of subduing nature. And this interaction has never ceased, it goes on to-day. But the achievements of to-day are not the conquest of savage beasts, nor the solution of the problems of food and shelter and warmth. We are overcoming time and distance; we are conquering the barriers of sea and mountain; we are finding out the more hidden forces of nature, and subjecting them. The fruit of our inventions is not seen in rough flakes of stone lashed by sinew to rude hafts, but in the mighty movement of the railway train thundering across the continent, or the click of the telegraph as London talks with Calcutta. And every step in progress has been a step in the improvement of man's condition from the first to the last. And so it shall be in the future.

Artists depict the genius of invention as a voluptuous female figure, in various stages of imperfect attire, attended by innocent boys in their primitive nudity, and with gear wheels and anvils and other rough equipments of the artisan in ill-assorted proximity. This is a feeble conception. The genius of invention is not a creature of delicate mold, but one of brawn and sinew. His voice is no gentle song of lullaby, but comes to us in the deafening clatter of Lowell looms and the roar of Pittsburg forges. Mighty and beneficent and responsive to human wants—this is the kind of song he sings in his rugged rhythm:

"I am monarch of all the forges:
I have solved the riddle of fire;

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The amen of Nature to cry of man
  Answers at my desire.
I grasp with the subtle soul of flame
  The heart of the rocky earth;
And hot from my anvils the prophecies
  Of the miracle years leap forth.

I am swart with the soot of my furnace,
  I drip with the sweat of toil;
My fingers throttle the savage waste,
  I tear the curse from the soil;
I fling the bridges across the gulfs
  That hold us from the To-Be;
And build the roads for the bannered march
  Of crowned humanity."

STATIC DIFFICULTIES IN TELEGRAPH WIRES.[1]

BY F. W. JONES.

The subjects of electro-static and electro-magnetic induction having so many distinct features of considerable scope, each of which is treated at length in the various text books, it is not possible, within present limits, to do more than furnish a few of the recorded methods of overcoming the detrimental effects of induction upon signals over land and ocean wires.

Briefly stated, the detrimental effects are as follows:—On a long submarine cable it is impossible to record upon the most delicate instrument, a signal at the distant end at the same instant that it is given at the sending end, notwithstanding that electricity may be said to have a velocity too great to be assignable. This retardation in the cable is due to what Faraday, Siemens, Varley and others, in early days, termed the Leyden jar property of the cable, or what is now termed electro-static induction. The current, if sent into the cable in a succession of dots of equal duration and at equal intervals, will be prolonged to dashes at the distant end, commencing very faint, rising to a maximum strength, and then gradually tapering off at the close after the battery has been removed. Should these dots be sent at shorter intervals they will appear at the receiving end as a continuous dash. When dots of the same duration and periodicity are sent through cables of the same length, their speed varies inversely as the product of the resistance and inductive capacity of the cables respectively, and the time of charging and discharging a cable varies inversely as the square of its length. Not only does the cable retard the signals, but the convolutions of the electro-magnetic apparatus, inserted in the circuit for the purpose of recording the signals, also exercises a retarding action on the current, due to electro-magnetic induction. As the signaling current passes around each one of the coils, there is an antagonistic or extra current aroused in all the adjacent coils flowing in a direction opposite to the signaling current, which it tends to extinguish and delay. In the straight conductor of the cable there occurs a similar but weaker effect. When the differential duplex system is applied to a cable there are, necessarily, sending and receiving instruments in circuit at each end, and instantly, after a signal is sent from one end, a ground is substituted for the battery, so that from the electrical centre of the cable near mid-ocean the current in the cable will divide, only about one-third of the current passing out at the distant end, and about two-thirds, returning through the ground above mentioned, at the sending end. As the receiving coils are always in the circuit, this returning current will produce a "kick" or false signal unless neutralized. The above-mentioned difficulties are experienced upon land wires, but in a much less degree, dependent upon the length, size and character of the wires, and their proximity to the earth and surrounding objects, and of the size and number of electro-magnets employed in circuit. There is also between parallel land wires an additional and serious difficulty, due to electro-magnetic induction, the magnitude of which depends upon the length and insulation of the wires and their distance apart, and on the strength of the signaling current, and the character of the signals.

About 1831, Michael Faraday coiled two insulated copper wires together around a block of wood, and connected one helix with a galvanometer and the other with a battery of 100 pairs, and discovered that when the battery contact was made and broken there was a sudden effect upon the galvanometer; "but that whilst the current continued to flow through the one helix, no galvanometrical appearances, nor any effect like induction upon the other helix could be perceived."

Faraday also discovered at this time all the other fundamental phenomenon of electro-magnetic induction. Nearly at the same time Joseph Henry discovered the phenomenon of the induction of a current upon itself in a long-coiled conductor.

M. Jacobi, of St. Petersburgh, Russia, is credited with being the first to introduce in a circuit a polarization battery, consisting of platinum immersed in sulphuric acid, for the purpose of counteracting the injurious effects of the residual magnetism in the electro-magnets. The line on which this was tried extended from St. Petersburgh to Moscow.

Werner Siemens published a very valuable article in the *Journal of the Society of Arts*, April 23d, 1858, in which he ranks as one of the earliest investigators upon the subject of the static charge of underground wires. The following are some extracts from both English and American patent records, showing a variety of inventions for overcoming static difficulties, and I leave to those skilled in the science of patent law all questions relative to the validity of the patents or priority of the inventions.

Eng. Pat.

13062. E. W. SIEMENS, Sept. 23, 1850.
To prevent the wire from being charged with electricity (in the manner of a "Leyden vial"); a connection between the earth and the line wire is established at each end of the circuit by means of a thin covered wire of german silver.

1852.

LATIMER CLARK noted the phenomenon of the slow transmission of currents through submerged wires.—*Jour. Soc'y Arts*, April 23d, 1858, p. 356.

2885. WHITEHOUSE, Dec. 12, 1853.
"In one mode of working this manipulator the depression of the key establishes a short circuit, thus draining off the current from the line wires."

2956. LATIMER CLARK, Dec. 20, 1853.
"An improvement in insulating wires used for electric telegraphs, with a view to obviate the effect of return or inductive currents."

H. V. PHYSICK, Dec. 31, 1853.

The electrical charge assisting in long lengths of insulated wire is discharged to the earth without having to pass through the needle coil. In a reversing handle constructed with the above-described improvements a spring connected to the coil and line wire makes and breaks contact with the earth-plate before and after the transmission of the signal.

Jan. 20, 1854.

Faraday communicated the results of his inquiries respecting the Leyden jar charge of buried electric conductors to the members of the Royal Institution. He then showed that the electric currents which he employed traveled at the rate of only 750 miles per second along buried wires.

371. C. F. VARLEY, Feb. 16, 1854.
Key so arranged that when at rest a current is completed through the line wire, two of the springs being in connection with the battery poles respectively, one with the switch, and a third with the earth. On depressing the lever to transmit a signal the circuit is broken, an earth connection with the line wire made to discharge any residual electricity, and the current reversed
"Peculiarly adapted to submarine or subterranean wires of great length."

1225. E. O. W. WHITEHOUSE, June 2, 1854.
"The induced or earth current in subterranean and submarine line wires is neutralized or dispersed in three ways, viz.:
1st. By alternating currents.
2d. By an adjusted amount of conduction to earth.

1. Read before the American Institute of Electrical Engineers, May 19, 1886.

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3d. By short-circuiting the current in order to divert it from the instrument; to obtain infinitesimal earth contacts platinum wires (respectively connected with the line wire and earth plate) are welded into a glass tube containing distilled water or other fluid."

2555. C. F. Varley, Dec. 5, 1854.

Condenser made of sheets of tinfoil and alternating sheets of oiled silk. Says they enable him to work to very great distances through submarine cables, subterranean wires, etc.

1318. C. F. Varley, June 9, 1855.

Invention consists of improvements whereby the speed of transmission is increased, and the distance of direct communication is extended, especially in the case of very extended submarine lines. "The key used for working by means of the patentee's, translates into the Morse system." In this key, when in a state of rest, the line wire circuit is completed through a relay by means of a tail-piece to the key lever which rests on a stop; the metal key lever being connected to the line wire and the stop to the relay, a small contact lever is pointed (by spring checks) on to the fore part of the key lever, and acts against stops, by which means, when the key is depressed, it puts the line wire into circuit with the most intense of two batteries, each of which are in connection with the earth. On the rising of the key the circuit of the larger battery is broken, the smaller battery sends an opposite current through the line wire, and finally the line wire circuit is completed through the relay.

When the key lever is quite depressed, and the line wire is being charged by the larger battery to signal at the distant station, the tail of the key lever comes in contact with one terminal of a resistance coil, the other end of which is in connection with the earth. This coil consists of a great length of fine iron wire, offering great resistance to the passage of electricity, and is employed to equalize the amount of charge which the wire received for different durations of the time of contact in making "dots and dashes."

The following difficulties are obviated by the use of the improved translators. The shortening of the short marks or "dots" made by a marking telegraph by repeated translation; this effect occurs in consequence of the time required to magnetize the electro-magnets and to move the armatures, it is also owing (in the case of submarine telegraphs) to the wire not being fully charged by the momentary depression of the finger-key at the transmitting station.

The lengthening of the long marks or dashes in submarine telegraphs, the first dash may give so great a Leyden jar charge to the wire, that its effect may not subside during some few subsequent contacts at the transmitting station, and thus make a dash and a series of dots appear at the receiving station as one long dash.

The discharge of the Leyden jar charge (in the case of submarine telegraphs) by and through the relays; this may either take place through the receiving relay after a signal has been given and the line wire circuit is connected with the said relay, thus inducing so much permanent magnetism in its electro-magnets "as to derange it from printing with the weak currents from the distant station," or (in the case of a "translator" placed between two submarine circuits) from the second circuit to the first and from the first to the second, and so on alternately (through the respective relays), until the exhaustion of the batteries.

"When a signal was made at one end a current would " be translated into the second circuit, and when the bat- " tery contact was broken at this end the translators " would also break contact with the battery it had put on " to the second circuit. This second circuit having be- " come charged like a Leyden jar, would discharge itself " through its relay, and so translate back a current to the " first station. The first circuit would now become " charged, and as soon as the second circuit had become " discharged, the charge of the first circuit, by returning " through the relay, would translate back again a current " through the second circuit.

"Long submarine circuits, submarine cables of the " usual dimensions 200 or 300 miles in length. The length " of time required to charge and discharge, in consequence " of the very great resistance offered by the wire, is such " that to communicate at a commercial speed it is neces- " sary to measure out the electricity in such a way that " the intensity of the charge shall not be greater with a " long contact than with a short one. This can be effected " by the induction plates of my patent, dated Dec. 5, " 1854."

Figure 34 of patent is an arrangement for effecting this purpose, and is represented as applied to a Morse machine for translation.

The line wire is first disconnected from its relay; secondly, it is connected to the primary coil; thirdly, both the line wire and primary coil are put in contact with battery when the electric current divides, a large portion going around the primary coil, the remainder through the secondary coil to line.

"The circulation of the current round the primary coil " induces a very powerful but momentary current in the " secondary, which gives a charge or tone to the wire.

"The primary and secondary are made adjustable. " When the signal is completed, and the lever begins to " rise, the battery contact is broken. The consequent " cessation of the current round the primary coil causes a " powerful current to circulate through the secondary " coil in the opposite direction, discharging the wire."

1855.

Mr. E. O. W. Whitehouse showed the effect of oppositely charging a submarine telegraph conductor in neutralizing the Leyden jar charge.—*British Association Report for* 1855.

2089. Werner Siemens, Sept. 15, 1855.

Object of invention is to obviate the effect of the static or residual charge on long lines of submarine or subterranean telegraphs; consists of using a set of two insulated wires placed in close proximity to each other in the same insulated coating without using the earth as part of the circuit.

2103. C. T. and E. B. Bright, Sept. 17, 1855.

Magnetic regulators adjustable at various distances from the needles increase the sensitiveness of the needles, and protect them from the effect of return currents. In using very powerful secondary currents an arrangement is adopted to protect the receiving coils from the effects of the return currents.

A (magnetic) arm connected with the line wire is free to vibrate between two stops, one connected with the coil terminal of the receiving instrument, the other with that of a supplementary coil and with the sending instrument. The normal position of the arm is in contact with the terminal of the receiving coil. The supplementary coil is so connected with the sending and receiving apparatus (with the receiving apparatus through the earth circuit) that the arm is not deflected by the action of the coil, when the first current traverses the line wire; the return current, however, deflects the arm, so that the supplementary coil is then in circuit, and discharges the return current. This last discharge replaces the arm in its normal position. Thus the receiving coils cannot be in connection with the line after any current has been sent, until the line has discharged itself by passing through the supplementary coil.

1726. E. O. W. Whitehouse, July 21, 1856.

Employs one insulated wire as a return wire in lieu of earth circuit.

——. C. F. Varley, Dec. 24, 1856.

Improvement in induction coils, also key arrangement in connection with the same.

In one arrangement the currents induced in the secondary coil, both by the breaking and by the making of the primary circuit, are turned in one direction, thus sending two currents in the same direction along the line wire by the depression of the key, and two currents in the opposite direction during the rising of the key to its normal position.

To enable the currents to be transmitted in the above described manner, the key lever and its tail, respectively, make contacts with studs in contact with the other pole. A commutator arrangement, or an arm projecting vertically from the key lever, enables both the secondary currents to be transmitted in the same direction along the line wire. In another form of key adapted for long submarine circuits, a handle or winch is placed on the axis of a contact making a cam wheel, and of a commutator arrangement similar in principle to that of the first key.

A key for working with a primary coil only. A key lever and its tail (connected to the line wire) is so mounted, in connection with springs and studs that on being depressed it breaks contact with the relay, then makes contact with one terminal of a primary coil whose other terminal is connected to the earth, then with a battery pole as well as the coil, the remaining battery pole being in connection with the earth. On rising to its normal position, the battery contact is first broken, thus allowing a momentary induced current from the coil "to flow through the line in the opposite direction to the original current."

The action during the depression of the key is, therefore, to send a divided primary current along the line wire, and during the rising of the key to discharge the line wire from the effect of induction. The same general arrangement may be used for translation.

The key with only the primary coil, "is of great use for

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"submarine lines, for, on the first moment of making "contact, the coil opposes a greater resistance to the current while it is being magnetized than when it is "charged, consequently the current flowing down the "line is more intense at the first moment than afterwards. "This neutralizes, to a considerable extent, the effect of "induction in the line wire, while the reverse current discharges the line. For overground wires, working with "Morse or other relays, a beneficial effect is experienced, "enabling the communication to be carried on more "rapidly. I use the same general arrangement for translation."

211. PIER ALBERTO BALESTRINI, Jan. 23, 1857.
Winding around the centre core of submarine cables on which the insulated wires are laid, a thin copper wire in long, open spirals, in order to carry off the induced electricity from the insulating material.

EDWARD HIGHTON, Jan. 26, 1857.
Invention consists in using an additional battery to neutralize the influence of the line current on the instrument at the sending station. The neutralizing current from the additional or counteracting battery, is brought into action by a short circuit made at the same time as the line circuit is completed, in the opposite direction, and only including the coils of the sending instrument. According to this arrangement, "there is no necessity for a separate counteracting coil wire (as usually employed), and each counteracting battery adds to the power of the effects produced by the main battery on the distant coil.

329. SIR WM. THOMSON, Feb. 20, 1858.—Sec. 15th.
In working through a telegraph line of considerable resistance, in both directions at once, to avoid the consequent violent action of the receiving instrument at the transmitting end, by transmitting signals from that end through it, the said receiving instrument is thrown out of circuit "during certain parts of the time during which a signal is being transmitted from that end." The time during which the signal is transmitted is regulated by the arrangement of cams and springs of the key. The time during which the receiving instrument is thrown out of circuit is regulated by a separate wheel on the same arbor with proper cams.

2180. C. W. SIEMENS, Sept. 30, 1858.
Avoiding the Leyden jar charge to a wire by allowing the Morse instruments to mark signals by dots only, instead of by dots and strokes. At a second row of dots the charge of the wire is discharged. A machine is used similar to that described in 2366 of 1854.

Eng. Prov. Pat.
2250. JNO. TATLOCK, Oct. 9, 1858.
In order to obviate the influences produced by the action of the Leyden jar charge in submarine and underground telegraph conductors, the conductor is made altogether of metal, instead of employing the earth circuit for half the conductor. The two wires which respectively conduct the forward and return current are separately enclosed in and surrounded with gutta-percha.

Eng. Pat.
2515. Communicated to R. BROOMAN, Nov. 9, 1858.
So arranging of the battery force that electric currents can be transmitted to any required distance without limitations, by the action of counter currents when the circuit is broken, the said counter currents being the effects of the Leyden jar charge of a long or subaqueous conductor. The battery is divided into two or more groups, one of which is at all times in perfect circuit, but without sufficient power to affect the receiving instrument. The circuit is continuity preserving.

181. LATIMER CLARK, & JNO. MUIRHEAD, Jan. 20, 1859 -Part 4.
A galvanometer that is wound with a long coil of fine wire, has its terminals connected respectively with those of a galvanic battery and with the ends of a short auxiliary coil of fine wire, thus providing two circuits for the electric current; as the relative proportion of the two quantities always remains constant, a measure of the whole quantity is obtained. The auxiliary coil is useful for reducing the strength of the return current in submarine cables.

607. WM. CLARK, March 8, 1859.—Communication from A. H. S. Treve.
To obviate some of the Leyden jar effects in submarine cables.

465. SIR C. T. BRIGHT, Feb. 20, 1860.
Return current may be discharged between the separate signals.
A key combined with a switch is employed, by which the conductor may be cleared of the residual effects of a former current, and the circuit changed for receiving, at one operation.

1209. C. M. GUILLSMIN, May 16, 1860.
Leyden jar charge of a long submarine conductor is not avoided, but is prevented from discharging itself between each signal, etc.

2047. THOMSON & JENKIN, Aug. 25, 1860.
The transmitting end of the line during the pause separating any two letters, words or sentences, is connected with a third source of electricity, at a potential intermediate between those potentials used in connection with the first and second contacts.

2116. C. W. HARRISON, Sept. 1, 1860.
A mode of dissipating the residual or Leyden jar charge of submarine conductors. Use of primary and secondary coils.

3453. C. F. VARLEY, Dec. 26, 1862.
1st. For working long submarine lines certain arrangements of induction plates with or without resistance coils, or induction coils at the transmitting end, are described and shown.
2d. Employing a "test" circuit, formed by induction plates and resistance coils, so adjusted to each other as to produce an artificial line, possessing the same amount of retardation as the cable itself.
This invention can be applied to almost if not all of the existing telegraph apparatus, viz.: It can be applied to the relay, or to the signaling instrument direct where no relay is used, as is the case with the needle telegraph, Thomson's reflecting galvanometer, Dignee's ink writer.
Another part of my invention consists in the employment of what I term a test circuit, formed by induction plates and resistance coils, so adjusted to each other as to produce an artificial line, possessing the same amount of retardation as the cable itself at the signaling end. In some cases, however, it may be advisable to connect the cable to the earth through an induction coil, consisting of a large bundle of iron wire surrounded by a long length of fine wire, the action of which is as follows:
On reversing the battery connections, the induction plates and battery combined send a short impulse into the cable, which divides one portion into the cable, the other through the induction coil to earth. At the first moment the iron of the induction coil offers resistance to the passage of the current, consequently, during the first instant of time nearly the whole force of the current is applied to the cable. As the iron becomes magnetized to its maximum this opposition ceases, but the plates have become charged in the opposite direction, and there is no longer any current passing from them into the cable to maintain the magnetization of the wire, the demagnetization of which induces a current in the coil and discharges the cable. In this way each impulse is followed by a short impulse in the opposite direction. By connecting the two armatures of the induction plates with a set of resistance coils, this reversal of the current is followed by a weak reversal in the same direction as the original current. The induction coil is represented as wound with two wires.

2217. RICHARD LAMING, Aug. 29, 1865.
The suppression, either wholly or in part, of retarding charges on the signaling conductors of electrical telegraphs, by means of a second conductor placed for that purpose around each of them, and made to act indirectly upon it by possession of a permanent electrical charge of the same character as that in use for supplying the signal.

2015. W. S. ANDREWS, July 9, 1867.
In another part of this invention (in cases where intermediate relays are not employed to discharge underground or submarine circuits, or to neutralize at the termini the current of discharge) the contact-maker of the Hughes typewriter is prolonged by a separate piece working on the same vertical shaft, which, by an arrangement of connections, affects the required discharge. In sending neutralizing currents, an insulated disc, on the vertical shaft of the contact maker, is in contact with a spring from the neutralizing battery.

2875. CHAS. T. BRIGHT, Oct. 4, 1869.
At the sending end a key is employed, in which the line wire is placed to earth during the intervals between the signals. A greater resistance than is used at the receiving end is inserted when a signal is made.

1044. C. T. VARLEY, April 8, 1870.
Dr. Gintl and Frischens' double-speaking apparatus and a hollow helix may be connected between the receiver and the line wire, the helix having pieces of iron inserted into it to remove the difficulty arising from the inductive capacity of the line. Helix to be of No. 26 silk-covered wire, 10 inches long, 1½ inches diameter inside, 4 inches diameter outside. Small iron rods are placed in the helix.

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1094. EDW. BULL, April 25, 1871. (Void.)
To prevent the current of the translator on the down line from passing through the coils of the translator on the up line. Condensers are used on cable circuits between the end of the line of each particular section and the earth.

2286. GEO. LITTLE, Aug. 30, 1871.
2d. The transmitting instrument is connected with the main line and with the earth. In the line leading to earth is one battery, the other battery is in a circuit united to the earth circuit at one side of the instrument and to the main line at the other side. The negative of one battery is connected to the negative of the other. When the transmitting current is interrupted a reverse current is brought into action to clear the line, etc.

1207. GEO. LITTLE, April 22, 1872.
In submarine circuits the transmitter draws from a condenser at a distant station.

3344. J. B. STEARNS, Nov. 11, 1872.
In working submarine lines a condenser is placed between the relay and the resistance coil, one part of its metallic sheets being in connection with the earth.

3701. GEO. K. WINTER, Dec. 6, 1872.
To obtain a high speed on long circuits.—Induction coil, etc.

761. GEO. K. WINTER, March 1, 1873.
In duplex working. The static induction of the cable is counteracted by magneto-electric, or by battery induction. The induction may be initiated in a local circuit.

861. WM. C. BARNEY, March 10, 1873.
To prevent the tailings which sometimes occur in electro-chemical telegraphs, the positive current (or that which acts on the recording paper) is sent from the transmitter to the earth plate direct.

1508. T. A. EDISON, April 25, 1873.
To enable perfect signals to be transmitted and received in cables and long telegraph lines, an artificial line is placed on the opposite side of the receiving instrument to the cable. The receiving instrument is thus interposed at the point of no electric tension. The artificial line has the same resistance and capacity for providing static charges as that of the cable.
Between the receiving instrument and the earth one or more condensers or other accumulators of static electricity are interposed.

2870. J. B. STEARNS, Sept. 1, 1873.
It is a well-known fact in telegraphy that a submarine or subterranean telegraph wire cable or line, and in a lesser degree, also, a land line or suspended telegraph wire or line, as used in the transmission of signals, is not only a conductor of electricity, but is also a reservoir of electricity, in the sense that a Leyden jar is a reservoir.
In the system known as duplex telegraphy, this charge and discharge become troublesome, and condensers, and also induction coils, have been employed to obviate their effect upon the receiving instrument, as described in specification of Nov. 11, 1872. To render the charges equal a portion of the artificial line is included between the instrument and the condenser. Instead of the condenser, an induction coil may be used, or the instantaneous current from the sending battery, or a signaling battery.

3879. J. B. STEARNS, Nov. 27, 1873.
The condenser may be in the form of a submarine cable having great resistance and capacity to neutralize the effect of the static charge returned from the cable; mechanical, hydraulic or pneumatic means may be used in the receiving instrument. The static balance may be effected independently of the magnetic compensation; in this case the condenser may be of small capacity. The receiving wire of a differential receiving instrument may be used as a bridge wire of a duplex bridge, in connection with a condenser or induction coil, charged and discharged through the other wire; or the receiving instrument may be wound with three wires, two used in the ordinary (differential) duplex working, the static compensation being effected by means of the third wire. Instead of the third wire a separate compensating means may be employed.

439. HENRY HIGHTON, Feb. 3, 1874.
The object of this invention is to obviate retardation in submarine cables.
At either end, or at each end of the line, also at an intermediate point thereof, an arrangement of pairs of plates is placed. The pairs are of metal or carbon, arranged as a galvanic battery, except that the plates of each pair are similar, and only one conducting liquid is used.
The electrical effect of this is similar to the mechanical effect of a spring in machinery, and immediately the electrical impulse ceases, the original electrical condition of the line is restored by the reaction of the plates, so as to be ready to receive a fresh impulse.

822. C. LEMAN, March 6, 1874.
A neutralizing current is sent between signaling currents.

1966. J. W. BROWN, June 5, 1874.
When transmitting a dash to the receiver, a strong current is sent, then an earth contact is made through the compensation pen, then a second strong current, and finally a reversed current. Permanent leak and magnetic shunt are shown, to obviate running the dashes and dots together, and to increase the speed.

2539. FOOTE and RANDALL, July 20, 1874.
To prevent tailings in an automatic telegraph two currents of opposite polarity are used, one for marking, the other for clearing the line.

4063. W. E. SAWYER, Nov. 26, 1874.
In an automatic telegraph a variety of devices are show to clear the line of tailings. At the cessation of an impulse, a perfect ground contact is made at the transmitting station. Induction coils and equating batteries are included.

684. A. MUIRHEAD and H. A. TAYLOR, Feb. 24, 1875.
Improvement in the arrangement of a condenser for artificial lines of a duplex.

2351. W. E. SAWYER, June 28, 1875.
Battery, induction coils and resistance are introduced in the line at the receiving end to prevent the effect of tailings.

3374. JOHN MUIRHEAD, Jr., Sept. 27, 1875.
Eliminating disturbances or kicks that take place on receiving instruments in duplex working, by connecting up so the instrument is not immediately in connection with a circuit of high capacity. Increasing the capacity of the instrument, and arranging the sides of the bridge so as to have capacity to receive a charge; introducing a condenser of small capacity, with variable resistance, at a suitable point in the artificial circuit; placing the primary wire of an induction coil (in connection with the extremity of the bridge at one end) to earth, and to make its secondary coil a shunt to the recorder.

47. BENJ. SMITH, Jan. 5, 1876.
To prevent the "kick" an adjustable resistance is inserted at the termini of the cable, between the Wheatstone bridge, or other differential arrangement, and the artificial line.

2541. WM. DICKENSON, June 19, 1876.
Grounds the line when making a signal, causing a partial discharge of the line.

2564. A. and J. MUIRHEAD, June 21, 1875.
To make the cable and artificial line of a duplex similar, condensers, induction coil and resistances are variously disposed.

2941. J. W. BROWN, July 19, 1876.
To increase the speed of recording dots and dashes, employs positive and negative currents, which are transmitted through two rows of perforations in a paper strip, also making an earth contact.

American Patents.

125582. G. LITTLE, April 9, 1872,
A condenser in combination with electro-magnets, a rheostat and constant current.

126847. J. B. STEARNS, May 14, 1872.
In a telegraph apparatus for double transmission, the combination with the relay at each station of a condenser for the purpose of neutralizing the effect of the return current due to the static induction of the line.

134867. T. A. EDISON, June 14, 1873.
Neutralizing any earth or extra currents in automatic instruments, by a weak constant local current, preventing tailings and blurs in the writing.

135531. T. A. EDISON, Feb. 4, 1873.
Reversed induced currents from electro-magnets in branch circuits, neutralizes residual or extra current in main line, and thus avoids blurs or tailings.

136873. J. B. STEARNS, March 18, 1873.
Electro-magnets are arranged in a branch circuit from the equalizing magnet circuit, the extra currents therefrom neutralizing the static induction upon the receiving relay.

136876. J. B. STEARNS, March 18, 1873.
A shunt circuit is established around relay by action of its own armature lever, or by the lever of the sounder it controls, thus lessening retardations and ensuring decisive action.

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141772. T. A. Edison, Aug. 12, 1873.
Part of main current shunted through branch circuit. Effect of extra line current neutralized by an extra current from a local battery regulated by a rheostat.

141773. T. A. Edison, Aug. 12, 1873.
Line kept statically charged by the main battery, whose circuit is made and broken with immense rapidity by a pulsator resistance, being such that these currents do not affect receiver; transmitter in shunt around the resistance. Receiver has two or more pens in circuits, having shunts containing magnets of varying size.

141776. T. A. Edison, Aug. 12, 1873.
The use of an opposition or secondary battery of weak power, at one or more points, to act in the main line in opposition to the pulsations from the transmitting instrument, to free the line of surplus or static electricity.

142486. G. Little, Sept. 2, 1873.
Condenser or coil applied in a branch circuit to electromagnet, to neutralize effect of induced current.

147311. T. A. Edison, Feb. 10, 1874.
States that the static charge of a line proceeds in both directions from the centre of the resistance of the line, and that at such centre the tension of the static or extra charge is zero, and that if the receiving instrument be placed at that point there will be no tailings; and introduces an artificial line between the receiving instrument and the earth, to balance the resistance and static charge.

147313. Thos. A. Edison, Feb. 10, 1874.
Instead of a single electro-magnet in a shunt circuit to the receiving and transmitting instruments, as in his patent No. 135,531, a number are employed, with a switch, for throwing more or less into circuit, as in the case of the ordinary rheostat; also uses a rheostat in connection with the series of magnets.

153064. Foote and Randall, July 14, 1874.
In an automatic or chemical telegraph, the method of obviating tailings or blurs, and of effecting a ready discharge or freeing of the line, the same consisting of throwing upon the line, immediately upon each and every break in the circuit of the recording current, a current of opposite polarity.

In the *Telegrapher* (July 25, 1874), page 179, we find the following, over the signature of Geo. H. Grace.

"*To the Editor of the New York Tribune:*

"As to the assertion that it is undisputed that Mr. Edison is the inventor of the device for neutralizing the after current, I have only to state that it is well known that Mr. Edison's claim to that invention is and always has been, disputed by me. I used the magnets at each end of the line for the purpose described, long before Mr. Edison had anything to do with automatic telegraphy."

154479. C. H. Haskins, Aug. 25, 1874.
Condenser in branch circuit, connected directly with main line circuit, so that extra charges from line and from condenser pass over the same wire in opposite directions.

157469. G. D'Infreville, Dec. 8, 1874.
A sounder is utilized in a shunt circuit to counteract the static charge and discharge of the line wire.

158442. Wm. E. Sawyer, Jan. 5, 1875.
A combination is made of a line, its battery and contact point of an induction coil connecting the line to earth, and throwing the secondary induced current into the line for the purpose of clearing the same of tailings.

160581. M. G. Farmer, March 9, 1875.
Claims that when the circuit of a duplex apparatus is closed, the static charge in the line causes the coil in the main circuit to momentarily affect the armature before the equating coil acts thereon, and introduces an inductorium, the primary coil of which is in a local circuit, the secondary coil being placed in either the line or equating circuit, so that when the sending key is operated the secondary currents will oppose the effect of the line charge and discharge.

165620. Wm. E. Sawyer, July 13, 1875.
Throws into line battery currents of one polarity and an electro-magnetic induction apparatus, so arranged as to throw into the line currents of opposite polarity to the battery currents.

168248. T. A. Edison, Sept. 28, 1875.
A signaling electro-magnet is placed in the line with a secondary battery, and a shunt is placed around the instrument.

168385. T. A. Edison, Oct. 5, 1875.
Places an electro-magnet in each arm of the bridge of a bridge duplex, and also establishes a supplementary artificial circuit, in which is also placed an electro-magnet, the extra currents of which are intended to neutralize the static charge and discharge of the line. This invention is disclaimed by Mr. Edison on November 19th, 1878, on the ground that it is set forth in a previous application dated Sept. 1st, 1874.[1]

178223. T. A. Edison, May 30, 1876.
Shows a mechanical compensator, consisting of a flat spring attached to the armature lever of a differential relay, and a notched lever operated by a local circuit. The notched lever engages with the spring to mechanically neutralize the effect of the static charge and discharge of the line.

190898. Geo. B. Prescott, May 15, 1877.
To prevent the signals being shattered on the neutral relay in a quadruplex telegraph when reversals of current are used, an electro magnet is so located as to pull on the armature of the neutral relay in the same direction as the line magnets. This auxiliary electro-magnet is connected up in a condenser shunt around a rheostat in the bridge, so that the received currents give momentary energy to it through the charge and discharge of the condenser.

196833. W. E. Sawyer, Nov 6, 1877.
A regulator periodically puts the line to earth or to a discharging battery, for effecting the static discharge of the line.

207724. T. A. Edison, Sept. 3, 1878.
In a quadruplex the artificial line is provided with two or more condensers of varying capacity, and a like number of rheostats of varying resistance, for regulating the charge and discharge of the same to correspond with that of the line.

An auxiliary electro-magnet is placed opposite the electro-magnets of the neutral relay, to act in conjunction with the retractile spring. A polarized relay, included in the bridge wire, operates this auxiliary electro-magnet in a local circuit, through either its front or back stop, so that during reversals of the received current, the local circuit is momentarily broken and the false signal avoided.

201374. Charles H. Wilson, March 19, 1878.
The detrimental effects of induced currents between lateral line wires are neutralized upon single wires by the interposing condensers and induction coils between them; and upon duplexed and quadruplexed wire by interposing condensers, resistance and retarding coils between the artificial circuits, and making their discharge equivalent to that of the line.[2]

209241. T. A. Edison, Oct. 22, 1878.
The drawing shows a bridge quadruplex system, in the cross wire of which a polarized relay, neutral relay, and a rheostat are included. Around the rheostat is placed a condenser, which, like the relays, is only affected by the received currents, and acts upon the neutral relay, so as to steady its signals during reversals.

217304. Benjamin Thompson and Charles Selden, July 8, 1879.
A condenser is arranged to form a shunt around the duplex relay coil situated in the line circuit.

225140. F. W. Jones, March 2, 1880.
A condenser is arranged to be charged by a separate battery, and to be discharged directly into the line through a system of duplex, employing single coil relays. This only obviates the effect of the discharge of the line wire.

238912. F. W. Jones, March 15, 1880.
A shunt of double-wound resistance, to obviate the effects of extra currents in a telephone circuit.

230802. Alexander Muirhead, Aug. 3, 1880.
A method of adjusting artificial lines or compensating circuits in systems of duplex and multiplex telegraphy;

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1. On referring to the files for Sept. 1st, 1874, we find that Edison filed a caveat for the following arrangements for meeting static difficulties in both bridge and differential duplex systems. 1st. Subdiving the condenser and resistance coils in the artificial equating circuit to more nearly coincide with the line wire or cable in the time of charge and discharge. 2d. The arrangement of a subdivided artificial line, with a cable or land wire worked by induction from condensers. 3d. The introduction of an electro-magnet in a shunt around the coil of the relay in the artificial circuit. 4th. An electro-magnet is placed in the line circuit, between the dividing point and the coil of the differential relay; also, in the arm of a bridge duplex on the artificial side. 5th. A secondary battery is placed directly in the artificial circuit, between the relay and the compensating resistance. 6th. To obviate the detrimental effects of the discharge from relay magnets, inserted by mistake in the line and way stations, an electro-magnet is inserted in the artificial circuit, at such a point as will allow its charge and discharge to balance the one in the line. 7th. The primary coil of an inductorium is inserted in the artificial circuit, between the relay and the earth, and the secondary coil is connected to an extra electro-magnet, which acts on the relay armature in opposition to the line relay electro-magnet, so that it tends to counteract the effect of the static charge and discharge of the line.

2. In the *Journal of the Society of Telegraph Engineers* for 1879, Professor D. E. Hughes has a very instructive paper on the effects of induction between lateral wires. W. H. Preece, Professor Bell, and others, have also made valuable contributions on the same subject, which has been dealt with more particularly with reference to the telephone. As many patents have been obtained, both here and abroad, for shielding that most delicate instrument—the telephone—from induction effects, I will leave this very extensive branch of the subject to others more conversant with it, for elucidation.—F. W. J.

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which consists in inserting an adjustable leakage circuit in the artificial line, and varying its positive to closely imitate the conditions of the line wire. This improvement was patented in England Feb. 24, 1875.

231904. J. E. FENN, Sept. 7, 1880.—Also,

236321. J. E. FENN, Jan. 4, 1881.
An adjustable electro-magnet is placed in the line next to the receiving instrument, to neutralize the static discharge of the line.

234347. T. F. TAYLOR and GERRITT SMITH, Nov. 9, 1880.
A condenser is placed in a shunt between the line and earth at the sending station, for the purpose of prolonging the duration of the outgoing currents.

237595. CHAS. A. RANDALL, Feb. 8, 1881.
A device for sending alternate impulses to line, and thus free it of tailings.

238094. GEORGE D'INFREVILLE, Feb. 22, 1881.
The capacities of the main and artificial lines are made equal at the instant of transmitting a signal, by automatically diminishing the resistance in the artificial circuit for an instant only, and then restoring it to its normal condition.

238399. F. W. JONES, March 1, 1881.
A shunt is placed around an electro-magnet, to prevent its extra currents from destroying the voice waves of telephonic communication.

238448. GERRITT SMITH, March 1, 1881.
A device for killing the static discharge. One pole of a condenser is attached to the main line and the other to a supplementary artificial line, which passes to ground through the coils of the home relay, thus permitting the re-acting discharge of the condenser to neutralize that of the main line.

244218. S. D. FIELD, July 1, 1881.
To avoid the difficulty of the static charge and discharge of a line on a duplex, the receiving instrument is short-circuited, and the bridge wire (in which said receiving instrument is located) is broken for an instant, both on the opening and the closing of the home key.

253154. C. L. BUCKINGHAM, Jan. 31, 1882.
To avoid troubles due to static charge and discharge in a duplex, a normally closed bridge unites the artificial and main lines at points beyond the differential receiving instrument, and the static charge and discharge are caused to act equally upon both coils of the receiver, by reason of the bridge. This bridge is broken by a signal from the distant station.

257499. J. W. LARISH, May 9, 1882.
In a duplex an electro-magnetic shunt is provided around the artificial line coil for avoiding the static difficulties, and the battery is momentarily connected through the home relay at the instant its connection with the main line is broken, for preventing false signals due to extra current charge.

258366. C. L. BUCKINGHAM, May 23, 1882.
An arrangement for rendering the receiving relay of a differential duplex system insensible to the effects of the inductive charge and discharge of the line, by causing both inductive charge and discharge, respectively, to be divided through the two oppositely wound coils of the differential relay.

258367. C. L. BUCKINGHAM, May 23, 1882.
Introduces in the line and artificial circuit, an extra differential relay, whose lever and back stop forms a bridge conductor, between the main and artificial line next to the main line, and at points of equal potential of the outgoing current.

258428. F. W. JONES, May 23, 1882.
In a duplex a branch line, including an electro-magnetic inductor, extends from a point between the main line and the receiving instrument to earth.

253636. J. E. FENN, May 30, 1882.
To prevent false signals upon the receiving instrument of the home station, caused by the extra current set up by the receiving instruments of a distant station, the artificial circuit is provided with electro-magnetic induction apparatus, interspersed with the equating resistance, so as to imitate in the artificial circuit the effects of the distant extra currents coming over the main line through the relay.

258957. B. THOMPSON and C. SELDEN, June 6, 1882.
A condenser is placed in the artificial line, between the transmitter and the receiving instrument, and so arranged as to utilize the charge and discharge of both faces in overcoming static disturbances.

259106. DILLON and BROWN, June 6, 1882.
In a system of tension duplex a device for overcoming the static discharge, by sending the secondary current of an induction coil through one coil of a double-wound relay —the primary coil of inductorium being in the local circuit of transmitter.

260208. F. W. JONES, June 27, 1882.
In a tension or two relay duplex an artificial current is formed around the relay nearest the line in the same direction as the line circuit. An electro-magnetic inductor is included in the artificial circuit, and opposes, by its extra current, the effects of the line static.

261916. S. D. FIELD, Aug. 1, 1882.
To avoid the effects of the static charge and discharge in a duplex, an electro-magnet, having a closed magnetic circuit, is placed in the main line near the receiver, and provided with a permanent magnet for adjustment with relation to the cores of the magnet, and a normally open shunt around the inductor, and a device actuated by the transmitter to close the shunt at the instant the current is set to or taken from the line.

268317. BENJ. THOMPSON, Nov. 28, 1882.
The poles of a condenser are connected to the main and artificial lines respectively at points of different potential.

280703. A. MUIRHEAD, July 3, 1883.
The potential of the battery applied to the artificial line of a duplex is modified by an electro-magnetic shunt, a separate battery being used for signaling on the line.

286867. B. THOMPSON, Oct. 16, 1883.
In a duplex a short circuit is completed around the sounder at the instant of the flow of the static charge and discharge.

291318. S. D. FIELD, Jan. 1, 1884.
In a duplex an electro-magnetic inductor is placed in the line circuit, and a shunt connecting the line with the transmitter is established around the line coil of the relay and the inductor.

291096. }
291097. } C. SELDEN, Jan. 1, 1884.
A local auxiliary neutralizing coil and a condenser are so connected to the relay and transmitter of a duplex as to be brought into action in opposition to the static discharge at the moment of its discharge.

293110. T. F. TAYLOR, Feb. 5, 1884.
An opposing battery, having less electromotive force than the transmitting battery, is placed in the line at the receiving station.

300781. F. W. JONES, June 24, 1884.
A static compensator or inductorium has one coil included in the main line circuit and the other coil in a supplementary convolution of the receiving instrument, so that secondary currents of the secondary coil are reverse to the static charge and discharge of the line.

304106. F. W. JONES, Aug. 26, 1884.
Duplex or quadruplex relays with three coils are employed, two of which are connected up as usual for the line and artificial circuit. A second artificial circuit, starting from the dividing point next to the transmitters, goes around the third coil of the relays to earth in the same direction as the line coil. In the second artificial circuit are rheostats and electro-magnetic inductors, so graduated as to generate extra currents equal and opposite to the static charge and discharge of the line.

309571. }
309572. } C. SELDEN, Dec. 23, 1884.
An auxiliary electro-magnet in a local circuit is arranged to exert its force on the armature of the line electro-magnet in opposition to the coils of the relay. The transmitter momentarily closes a local battery around the auxiliary coils at the instant the discharge line discharges. Also an ingenious arrangement of polarized sounder, reversing relay, battery and local circuit, so as to withdraw the local current from the sounder at the instant of opening or closing the sending key.

313787. H. VAN HOEVENBERGH, May 10, 1885.
In a quadruplex telegraph a method of preventing false signals upon the receiving instrument, controlled by the armature of the neutral relay upon the reversal of the main line current, which consists in momentarily neutralizing the local current, actuating said receiving instrument by means of an opposing electromotive force.

319428. GERRITT SMITH, June 2, 1885.
In a quadruplex telegraph system, in which reversals of current are employed for the transmission of one set of signals, a neutral relay provided with two coils, one of which is embraced in the main line and the other in a branch, which includes a condenser, and is connected with the main line between the neutral relay and the earth and with the earth.

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310684. F. W. JONES, June 13, 1885.
A static compensator for duplex and multiplex telegraphs, consisting of an inductorium, one coil of which is in circuit between the main line and the point of division of the main and artificial lines, or beyond the point of division of the main and artificial lines, while the other is in a closed circuit, including means for counteracting the effects of the static charge and discharge current upon the receiving opposite.

320987.
321404.
322333.
323239. F. VAN RYSSELBERGHE, June 30, 1885.—July 28, 1885.
The method of rendering telephonic or other electric currents—whether primary, induced or derived—inaudible in telephones, consisting in rendering gradual the emission and extinction of the telegraphic or other electric currents, by the introduction of an electro-magnet in the circuits; also by the attachment of condensers.

322692. P. B. DELANY, July 21, 1885.
The combination of a main line synchronously actuated apparatus connected with each end of the main line, a table of contacts and a rotating circuit, complete at each end of the line, which traverses over the table of contacts and successfully places the main line in connection with each of said contacts. Static discharge contacts arranged between the first-named contacts, and connected together and to earth, and a resistance between the static discharge contacts and the ground.

322739. L. O. MCPHERSON, July 21, 1885.
In a quadruplex telegraph a condenser having one pole connected with the conductor leading to the said instruments, and the other connected with the earth, whereby said condenser will receive a charge opposite to the static charge occasioned upon the main line.

327097. ALEX. MUIRHEAD, Sept. 29, 1885.
A supplementary condenser and rheostat are included in a shunt around the condenser in the artificial arm of the bridge.

326892. F. VAN RYSSELBERGHE, Sept. 22, 1885.
To prevent false signals or reversals, a relay is placed in a branch wire from the main line to a condenser, the other side of which is to earth. The local points of this relay controls a battery, which actuates a supplemental or holding electro-magnet, acting upon the same armature lever as the neutral relay in the main circuit.

THE INSTALLATION AND MANAGEMENT OF ARC LIGHTING PLANTS.

BY J. M. ORFORD,

Superintendent of the Bridgeport (Conn.) Electric Light Co.

(Continued from page 224.)

CHAPTER III.

BOILERS.

IT has been said that whoever causes two blades of grass to grow where only one grew before is a benefactor to the human race. The man who will show us how to utilize coal so that one pound will do what two pounds hitherto have been doing, will certainly be a benefactor to electric light people. For dynamos and engines Connecticut will send to Minnesota, and Minnesota to Rhode Island, Maine to New York, and New York to Massachusetts, and so on, while for boilers and their appurtenances, all, or nearly all are willing to hand over the making and setting to the local boilermaker and bricklayer. Just why they do this, we do not know, unless the engine is considered all important, and the boilers—well, any one can make and set a boiler. That so little consideration is given to the construction and setting of boilers is to be regretted. The power is derived in the first place from an arrangement of fire and water, and although they are good servants when properly handled, they become very destructive agents when ignorantly treated. The more dangerous to life and property an element becomes, the more imperative to surround it with safeguards. The majority of the states recognize this fact, and have appointed state boiler inspectors, whose duties are no doubt arduous, and faithfully performed, and whose advice would be of incalculable advantage, if one only knew where to find the gentlemen. The proper time to begin inspecting your boiler is while it is in the hands of the maker. If you cannot undertake this, or have not the experience sufficient to justify you in assuming the responsibility, then order from a boiler maker who has an extended and long established reputation for turning out well designed, and well constructed boilers, and who will not accept an order to make a boiler unless the price admits of his doing justice to himself as well as to the customer.

There are many forms of boilers in use, but generally speaking there are only two distinct types in this country, the tubular and sectional. The former are made everywhere, the latter by parties who make a special business of it, and who claim for their boilers immunity from explosions. Should you select horizontal return tubular boilers, we recommend that you insist on having a manhole in front under the tubes, so that the engineer can occasionally go inside and make a thorough examination. There does not appear to be much advantage in having a handhole in the rear. The trouble with it is that when it has been opened and closed in the event of its leaking, after the fire is lighted, there is a difficulty in going in and tightening it. See that the material used in constructing the boiler is of the very best by having the tensile strength tested, that the plates are not injured by punching—some prefer drilling—that the drift pin is not used, that the plates are properly rolled so that undue strain is not put on the bolts to draw them together, that the rivets are properly formed, and that only the minimum of calking has to be done, and that very carefully.

In a well regulated boiler making establishment, special tools have been designed for rolling, marking, punching or drilling, and riveting the plates, and the consequence is that boilers are turned out so efficiently put together and finished that no hand-made boilers can be compared with them. However admirably designed and constructed a boiler may be, its good features can be easily rendered nugatory by careless and ignorant setting. The ordinary, or it may now be termed the old fashioned, way of setting boilers was by building a bridge wall from the floor to within six inches of the shell, placing the grate bars in front. The heat and gases arising from the furnace pass over the bridge to the back end of the boiler, there entering the flues or tubes, passing through them to the front of the boiler, thence into the smokestack. Even this is superior to some methods. The chemistry of combustion teaches us that coal consists chiefly of carbon and hydrogen, two substances which in themselves will not produce heat, but when heated, and oxygen allowed to mingle with them, the combination produces heat. The air we breathe is oxygen and nitrogen, in the proportion of 21 of the former to 79 of the latter, so that by admitting air to the furnace we have combustion which produces heat and gas. This gas will pass off through the flues and smokestack, and be wasted, unless more air be allowed to mix with it, but the gas and air although mixed, will not burn unless they are lighted. As in the case of illuminating gas which cannot be ignited with a red hot iron, but requires something approaching a white heat, or a lighted match; therefore the gas must not only be heated to a temperature sufficient to produce chemical action of the gas and air, but very much higher, because the cool air reduces the temperature very considerably, and if it brings it too low, there will not be any action, hence the advantage of admitting heated air into the furnace. Now just as rapidly as the gas is given off by the first mingling of the carbon, hydrogen and oxygen, so rapidly must air be admitted to mix with the gas and reproduce combustion, always provided that the temperature of the gas and air is high enough to produce chemical action. The question then is, how are we to introduce air, so that the gas and air will be thoroughly mixed, and of a temperature high enough to burn. We can have an abundance of air by opening the furnace door, or having

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a perforated door, but this would reduce us to one combustion, as we have already seen, because the current of cold air would be so great that the gases would be so reduced in temperature they would not ignite. We can admit air through the grate bars, but this air is required for the carbon and hydrogen to form the first combustion and give off gas. If we admit air beyond the bridge wall we would derive very little advantage from the combination owing to the brief space of time, which would elapse before they entered the flues, where combustion ceases. If air is admitted in a strong stream, the gas and air will mix only on the surfaces where they are in contact with one another, and will flow along in this manner and enter the flues. In the fire-box of locomotives air is admitted over the fire in jets, which mixing with the gas at the proper temperature, produces carbonic dioxide. The fires in locomotives burn very fiercely. For stationary boilers something of the same nature is required, with this improvement, that the air should be heated, so that when entering the furnace the temperature will be reduced as little as possible, and so save fuel. If this theory is correct, then what we require is a method by which hot air can be admitted into the furnace in small jets, and right over the fire, so that there will be time for the gas and air to mix thoroughly and burn before reaching the flues. Bear in mind the gas and air will burn only when up to,or above a certain temperature, that they must be thoroughly mixed, that the air must be in sufficient quantity, and that if admitted cold, it reduces the temperature and so wastes fuel, and that if more air is admitted than required for the volume of gas, it does no good, if not a positive injury. In order to attain good results from coal, thoughtful and attentive firemen have tried carrying their fires thin, so as to admit plenty of air through the bars, and no doubt they use less coal than with a thick fire, but most of the oxygen mingles with the carbon on the lower bed of coal, producing carbonic dioxide, but as this passes up through the fuel, carbon increases, and while more air is not forthcoming, the carbon mixes with the dioxide, forming carbonic oxide, reducing us to the first combustion, and the gas goes up the smokestack unconsumed. In this way you secure one good combustion, but you never can get a second which will amount to anything, consequently, you are not burning your fuel to any advantage compared to what you might do. It is owing to these facts that you find in one place nothing but the best bituminous coal used, and in another place, screenings, or the sweepings of the coal yard give excellent results. The difference in the cost of steam is apparent. The units of heat arising from the combustion of one pound of carbon converted into carbonic dioxide, is estimated about three times greater than when converted into carbonic oxide. The latter is imperfect combustion, the former complete combustion. A great many experiments have been made in order to ascertain the average amount of air necessary to affect the most complete combustion under the varying condition of the fire; and patents have been issued covering the various methods of regulating the admission of air over the fire, through the bridge wall, and in combustion chambers back of the bridge wall, and we repeat, it has been found that by means of these furnaces, an inferior grade of fuel will give as good results, as the old fashioned setting using the best coal, hence the importance of availing yourself of the most scientific setting in the market. A very common mistake in setting boilers is to have the grate bars too near the shell. A 60-inch boiler ought to be about 30 inches above the bars, so as to give plenty of space for combustion. This should be seen to before the front is cast, as the openings have to be regulated according to the position of the bars.

If you have a brick smokestack, build a flue of brick, or sheet iron, from the top of the front of the boiler in a horizontal line to the smokestack, and see that the flue has more area than the tubes in the boiler. A damper should be placed in the flue, and if you can have a damper for each boiler so much the better. In these days no one should be without a steam damper regulator, but it is a common thing to find people tell you they cannot use one. Some are even without dampers. What do they do when steam goes up? Open the furnace doors and run the risk of starting a rivet or a tube. This is not an infrequent occurrence. A steam damper regulator can be had for a moderate sum of money. The great trouble is there are too many worthless ones made. A good one should work for years without the slightest attention, and the steam ought not to vary one pound, although there are regulators which will not operate with less than a variation of 7 and even 10 pounds. A reliable and sensitive damper regulator is of great value, an unreliable one you had better be without. There are places where by means of a regulator, steam has not varied one pound in six months. Do not burden your boiler with a load of brick, or other material resting on the upper side of it. When the boiler is in position, and the walls are up to the brackets, get an inch pine board, and cut segments an inch thick, a little larger than the circumference of your boiler, place the segments over the boiler, about two feet apart and reaching down to the walls. Nail lath strips over the whole, then plaster over with fire mortar and on this set your bricks. The wood will char and crumble soon after the boiler is in service, then you have an arch over the boiler without any weight on it and the fire mortar will prevent the ordinary builders' mortar from touching the boiler, which in time would cause corrosion.

Feed pipes from the pump, to and through the heater, and on into the boiler, should be of brass, should enter the front of boiler, and be carried back near the rear end, so as to have the water discharged as hot as possible. Blow off pipes should be of brass until you reach the blow off valve, which should be a plain upright cock, so that there will not be any obstruction to the mud or sediment flowing out freely. The elbows and other parts which are cast, may be of iron, as cast iron does not corrode like wrought iron. For this reason all pipes in closed heaters should also be of brass. Open heaters are condemned by many because of the cylinder oil eventually getting into the boiler. Carry the steam pipe from the boiler 5 feet in a vertical line, then run to the rear, or front at least 12 feet, then enter the main steam pipe. This gives room for expansion. Wherever steam pipes drop, have a drip in the lowest part. Where two or more boilers are connected to one main, be sure that the main is of sufficient capacity. If the pipe leading from each boiler is 4 inches, the main for two should have double the area of the 4-inch. For instance, the area of a 4-inch pipe is 12.5 square inches, therefore the main should have an area of 25 square inches, or a 6-inch pipe which has 28.27 square inches. To find the area of a pipe or cylinder, square the diameter and multiply by .7854. A 10-inch cylinder has an area of 78.54 square inches 10x10x.7854 = 78.5400. Globe valves should be placed at the junction of each pipe with the main. All pipes containing live steam should be covered by some substance which is a non-conductor of heat. Have the floor of the ash pit cemented, and let the drip from water column run into it.

Your engine should be set on a solid foundation, and give it plenty of time to dry. Whether the foundation is brick or stone, set the engine on good large stones, unless cast iron plates are provided for the purpose. If you can bolt right down on the stone, so much the better, but it entails a great amount of labor for a large girder frame engine. A good cement for setting can be made of 100 parts sulphur and 12 parts iron filings, heat until thin, then use quickly. If you let it burn you must throw it away. Have drips from cylinder, steam chest, throttle, heater and lowest part of exhaust pipe; discharge into a sewer, and be careful that this pipe is always lower than the lowest part you are draining. Have the exhaust pipe considerably larger than the line steam pipe.

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PULLEYS AND BELTING.

Place the dynamos on a solid bed of wood, with some arrangement for shifting them to suit the belt. Avoid "idlers." As a rule the makers of dynamos have adopted pulleys too small for their work. If you were to adopt larger pulleys you might not be able to get the proper speed. To remedy this, when ordering dynamos instruct the makers to supply wood pulleys, or to withhold the standard iron pulleys and allow you their cost. You can then purchase wood pulleys of the standard size, and the result will be equal to the use of an iron pulley, having 30% more surface. We also recommend wood pulleys on the counter shafts. They are not more expensive, less liable to split, are far lighter, and are quite as durable as iron pulleys provided the belts are free from rivets, as they should be. Regarding belts, a double belt made up of two thin belts is far superior to a single belt of the same thickness as the double one. They are more durable than the best single belts, and you can run on either side, if you take care that rivets are not used Have all belts made endless, and after running a few days, open the splice and cut a piece out. If the belt is of good material, it will run for years without any more cutting, unless you have undue tension on it. When belts are constantly being "taken up," something is wrong. The principal cause of this, is, that you are trying to make the belts transmit more power than your arrangement of pulleys and belts are capable of performing under favorable circumstances. Very likely your pulleys are too small, or you may be using vertical belts, with the driving pulley overhead. In this case the cause is self evident—Your belt instead of hugging the lower pulley is all the time being thrown away from it Your belt slips—by means of your machine shifter you tighten the belt—result—stretch the belt, heat the bearings, and waste oil. In both cases you can remedy this to a very considerable extent by using wood pulleys of the same size as the iron ones in use.

POLES AND WIRES.

In large towns there is less difficulty in setting poles and running wires after you get the right of way, than in small ones, owing to the fact that in busy commercial centres, trees do not fill the streets as in country towns. In this respect the towns of New England are a terror. Go into any of their streets, even the principal ones, and you find an avenue of trees. To dodge them requires considerable ingenuity. Poles have to be set first on one side of the street and then on the other side. Consequently each pole is an angle pole, and without any possibility of guying it. Good sound heavy poles 30 to 40 feet long and 7 to 8 inches at top should be used, set six feet in the ground, and leaning well over the sidewalk. They may not appear symmetrical, but they will come nearly to a vertical position after a time, and you will be fortunate if they do not lean toward the centre of the street. They ought not to be more than 150 feet apart. Put a four pin cross arm on the top, and six pin arms underneath, two feet apart. Do not use eight pin cross arms, the weight of the outside wires is liable to break the arm. The centre pins should be 20 inches apart, the other pins 12 inches. Wherever you can put on a guy, do so, before any wires are on the poles. Telephone people make serious complaints about the trouble caused by electric light wires, not only through wires getting in contact, but from induction. Our old friend of twenty years ago, "induction" is a horse of another color in this blessed year of 1886. Then he was a nuisance to be got rid of by various contrivances, now he is harnessed and indispensable. Induction is a very popular word with every telephone employé, and gets blamed for many things he is entirely innocent of. It should be your object to run wires so that you will not have trouble yourself or put any one to inconvenience. Having set your poles, and put on the cross arms and glass insulators, start from the station with two wires; call the right hand one positive, the left hand negative. Take the two centre pins on the top arm. As you go along you find there is a lamp to go in on a street to your right. On the pole at the corner put on a cross arm parallel with the two wires and under the top arm, call it a **T** arm. Put a good sound rubber hook in the under side of the top arm, alongside the pin on which the right hand wire is fixed, bridle the right hand wire from its pin on top down to the **T** arm, and run down the street to the lamp returning to the other pin on the **T** arm, and bridle up to the rubber hook, then go ahead with both wires as before, cutting in lamps right and left in the manner described. When you have cut in as many lamps as the machine will carry, join the two ends together. You have completed No. 1 circuit, and the telephone exchange will not complain of induction from that one, nor from any other circuit, if you keep the two wires side by side throughout the run. There are some advantages in running circuits in this manner. Should the circuit be open, go half way down and strap a piece of wire across. If that does not close it, remove strap, come nearer the station, and do the same thing. You can thus locate trouble very quickly. If the circuits have long loops, put a cut-out box on each loop. Do not start out with one wire, going round the town with it, then returning to the station. During rainy weather when insulation is low, and circuits are run in the form of a circle you have strong currents passing through the earth from one leg of your circuit to the other, and any telephones which are grounded within the circle will not be of much use. With parallel wires the leak would be from one support to the other, and being close together cannot possibly affect telephones. Some people say the earth is like a roaring lion seeking to devour all the electric currents it can get hold of. Put a "detector" in your pocket and go over a circuit on a wet night. Tap the positive wire near the station by putting a connection through the detector to a ground having a high resistance, or to a good ground with a piece of wet string inserted. Observe the direction of the deflection. Go towards the centre of circuit and tap again, observing the direction of deflection as before. Now go near the station and tap the negative wire, the direction of deflection has changed. At the first tap, the current was passing into the earth, second tap the same, but not so much of it; third tap the current was leaving the earth, and returning to the negative wire, and hence the change in deflection. In doing this keep the same binding post of "detector" to the ground during each observation. This same thing goes on more or less, summer and winter, wet or dry, varying according to the insulation of the line, and the complaints of the telephone exchanges are due to this cause as much as to induction.

It is far more difficult to insulate a line, consisting of a large copper wire, than to insulate an iron wire of the same size. Few people have any adequate conception of the nature of the currents they are dealing with. A very few years ago we would have considered a current having a potential of 3,000 volts, something which could not have been handled; to that give a current of 10 ampères and it would have been beyond our conception, as, indeed, it is now, to those who have studied it thoroughly. It is, therefore, very important that every precaution be taken to secure good insulation. On entering buildings it is usual to support the wires over the door or window by rubber hooks screwed into blocks of wood, which are nailed on the wall, covering the wires with soft rubber tubing. The wires have to be run between the awning and awning rods, or between the rods and the building.

This is frequently a place where trouble arises. The very best tubing should be used, and even then it should be carefully covered with some tape having insulating as well as adhesive properties The average soft rubber tubing is generally very poor material, and when exposed to the atmosphere deteriorates rapidly.

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A more reliable method is to dead end the wires in the hooks, and from there into the "cut-out" box use "leading-in" wires specially made for the purpose, and cover them with tape. The "cut-out" box should be protected from the rain. Where cables are used to cross a river endeavor to run the lamps on the other side on a circuit by themselves, but if they are too few in number, and you must have lamps on the same circuit both sides of the river, place a "cut-out" box where the line wire joins the cables on the station side, and protect the cables with good large lightning arresters. The little ones used on telegraph lines are not suitable for this purpose. If you want to run a wire from one side of a pole to the opposite side of the next, bridle it from one pin to another on the same pole, and keep all your wires parallel.

Where circumstances compel you to go on trees, use cross-arms painted as nearly as possible the color of the trees. Keep them down low and you will not have much trouble. Where you have to go on roofs of houses, and cannot get access to every fixture during the night, run each circuit to a central spot, where you have the privilege of going during the night. Put up a box large enough to contain three or more "cut-out" boxes, and from that box run loops to groups of lamps. If trouble arises on one of these loops, and opens the circuit at a point you cannot reach, cut that loop out. Have a spare wire from the station to each central box, so that if a wire opens between the station and box, you can use the spare wire. These, and such like things which will suggest themselves to your mind, will enable you to keep all or nearly all your lamps burning.

(*To be continued.*)

RESEARCHES UPON THE SELF-INDUCTION OF AN ELECTRIC CURRENT.[1]

BY PROFESSOR D. E. HUGHES, F. R. S.

NUMEROUS researches have been made upon the self-induction of coils of wire, and but few in relation to the influence exerted by the nature and geometrical sectional form of the electrical conductor when employed in straight wires as in those of a telegraph line with the earth as a return, or those of a single wide loop where the distance of the return wire is sufficient to prevent any appreciable effect from the *mutual induction* of separate portions of the wire upon each other; our present theories class all non-magnetic metals together, taking only into account their specific resistance and the diameter of the wires; they admit, however, a certain modification in magnetic metals due to their magnetic permeability, but we have had but little experimental evidence of the effect produced.

The whole subject seemed to me worthy of experimental investigation, and I have lately[2] given the results of a first series of experiments made last year. I have remarked since writing that paper many new and important effects, and I have made a new series of researches, the results of which I wish particularly to point out in this paper.

In my late researches I made use of a modified "Wheatstone's bridge," together with a portion of my "induction balance," by means of which the induced or extra currents from the wire under observation were balanced by a secondary current induced from an independent circuit; this gave excellent results, but the method has been criticised as having the fault of not being clear in its indications. In order to meet this objection and also verify the results which I had previously obtained, I constructed an entirely new bridge founded upon a most simple and well-known principle, and as the bridge admits of no change in the relative resistance of its sides, its action can be easily understood; it is with this instrument that I have made my new series of experiments.

The instrument consists of an ordinary Wheatstone's bridge, with the exception that a telephone replaces the galvanometer; there are in addition two coils of insulated copper wire, one in each portion of two sides of the bridge, by means of which the mutual self-induction of its convolutions can be increased or decreased as desired.

The electrical contacts are made either by a continuous periodic or tuning fork contact maker, or by a peculiar clockwork rheotome which I have made, in which a contact spring rests lightly on a wheel whose roughened surface is divided into eight equal parts of contact and insulation, by means of which we receive on the telephone eight equal periods of sound and silence each revolution of the wheel. We are by this means better enabled to appreciate feeble sounds than if they were continuous, and as the wheel can be made to revolve at any between two and ten revolutions per second, we have from sixteen to eighty periods of silence between each rubbing contact per second.

The following figure shows the theoretical plan of the electrical communications of the bridge:—

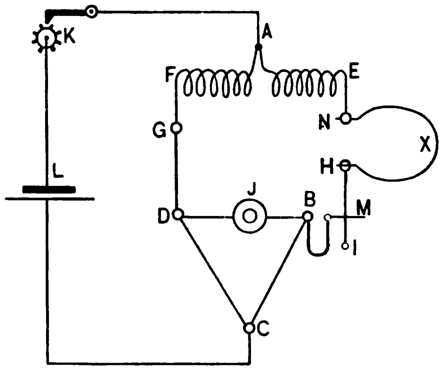

FIGURE 1.

A, B, C, D are the four sides of the bridge, the telephone J replacing the ordinary galvanometer; the sides CB and CD are formed of german-silver wire, each 50 cm. in length, 0.5 mm. in diameter, and 0.85 ohm resistance; the sides AB and AD have also 0.85 ohm resistance, so that the four sides have equal resistance, and this remains a constant during the whole series of experiments.

AE and AF is a continuous spiral of copper wire, formed of hard copper silk-covered wire of 1 mm. diameter and 4.80 metres in length, wound loosely on a boxwood cylinder of 3.50 cm. diameter and 30 cm. in length, on which it moves freely; the entire helix has 40 turns of 4 cm. diameter, each spiral being separated 5 cm. from each other; the spiral, however, is separated into two equal portions by giving a greater separation at the centre in order to allow it to be attached to a sliding collar of wood, by means of which we can press the spiral closer together on either side as desired; at E and F there are also adjustable collars of wood, and as the boxwood cylinder is graduated, we may (if the central collar is fixed) approach more or less either side of the helix, and read the degree of approximation of the coil, thus adjusting the mutual induction of each side to a perfect balance or zero. In practice I prefer moving the central collar, using the end collars only for the perfect adjustment of its zero, as we then have a double effect, viz., closing the coil say from A to F, increasing its mutual self-induction and at the same time decreasing the previously balanced induction of the coil AE, this not only gives a wider range of effect, but renders the scale readings more uniform; the end F of the helix is joined to about 10 cm. of german-silver wire, completing

1. Read before the Society of Telegraph Engineers and Electricians, May 27, 1886.

2. "Self-induction of an Electric Current in relation to the Nature and Form of its Conductor."—*Journal of the Society of Telegraph Engineers and Electricians*, January 28, 1886.

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the circuit from G to D; this supplementary german-silver wire is simply for the purpose of making the resistance of AD equal to DC, and its length should be adjusted to this purpose; the end of the helix E joins directly with the terminal N; the wire to be tested, X, is joined to N and H; from H to I there is a second supplementary german-silver wire allowing us by means of the contact slide M, which is in direct communication with B, to introduce more or less of the german-silver wire in the side AB. The resistance of the wire to be tested should always be less than that of the opposite side of the bridge, and we then make up the total resistance of AB by sliding the contact slide M until the resistance of AB equals AD.

It will be evident that in the whole series of experiments there can be no change in the resistance of either side whenever zero is found, the induction coils or balance having the same proportional current in all the changes of the wires under observation, the battery and telephone circuit present also a continuous absolute relation; we may, however, when desirable, keep the resistance from H to M a constant, and vary the resistance or the length of the german-silver wire GD, we then balance the wire X by an equal resistance on the opposite side of the bridge, but then the battery and telephone circuits no longer possess the invariable relations which are so extremely necessary in experiments of the nature of which I have been making.

The battery circuit is joined in the usual manner to AC, the current can be interrupted by the rheotome K, or by means of a commutator (not shown in the diagram) close the battery circuit and transfer the contact maker to the telephone circuit BD; this allows us to observe the effect of an intermittent current compared with that of a constant or steady flow. M. Gaugain has termed the period of a steady flow of current the *stable period*, and that in which a rise or fall of the current takes place the *variable period*; these terms have since been generally adopted by telegraph electricians, and in order to avoid introducing new terms they will be used in this paper.

It would require too much space to enter into the details of the construction of the bridge, special care is required in the construction of the balancing induction coils, and in securing perfect electrical contacts in all parts of the bridge; the induction balance requires calibration, and for this purpose I introduce as the wire X successive lengths of 10 cm. 1mm. diameter copper wire, thus forming a table of values throughout the range of the induction balance, or by equal increments of 10 cm. of copper wire up to 20 metres.

Having no unit of self-induction to which my results could be quickly and practically referred, I have adopted as unit the self-induction of a straight copper wire 1 mm. diameter and 1 metre in length; this gives on my calibrated induction scale 100 degrees, and it is to this standard that all the comparative force of extra currents mentioned in this paper is compared.

The self-induction of a wire is proportional to its length; consequently, a source of error might exist in the different lengths of the supplementary resistance wire HI introduced to balance the resistance of GD, but as we are enabled by the high specific resistance of the german-silver wire to obtain a very great change in resistance by a comparatively small movement of the sliding scale, this error in most cases of comparative experiments is but a fraction of 1 per cent., and when taken into account as it should be the error no longer exists.

The telephone used should be of the most perfect kind, and adjusted expressly for rapid and feeble sounds. I have found it best to employ an extremely soft Swedish iron diaphragm, without varnish or anything that can diminish or deaden the sound; its fundamental note should be higher than those generally in use, or at least 500 double vibrations per second, for we have to deal with extremely rapid effects which on short wires cannot be rendered evident upon a galvanometer, but which with a telephone in perfect adjustment are heard most distinctly with an electromotive force in the battery circuit ranging from 0.001 to 0.250 ampère.

In the sketch of the communications the wire to be tested, X, is shown in the form of a wide loop, but in practice the instrument is constructed on two separate frames of wood articulated together at D, by means of which we can separate the terminals NH, and introduce straight wires, sheets or tubes of lengths varying from 5 cm. to 1 metre.

IRON WIRES, 4 METRES IN LENGTH.

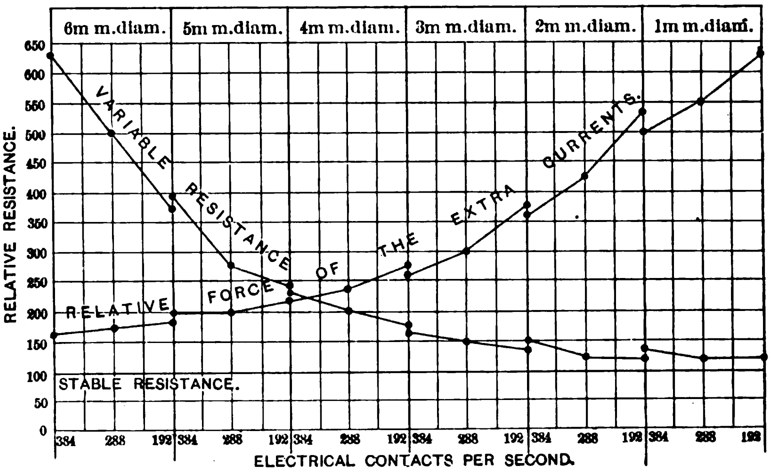

FIGURE 2.

The object of my researches being to observe the self-induction which takes place in straight wires, or in those of a single wide loop where the reaction from any return wire is at such a distance that its influence is not appreciable, I shall, therefore, use the term self-induction to indicate the effects due to the electric current in its own portion of the wire, and mutual induction to those where the reactions of different portions of the current and circuit react on each other, as in the case of coils; and although some theoreticians consider the two cases as the same, they are, as my experiments prove, entirely distinct, for we have, as will be shown, for copper wires a low co-efficient of self-induction with a high mutual induction, whilst in iron wires the reverse is the case, for we there have a high coefficient of self-induction with an extremely feeble coefficient of mutual induction.

INFLUENCE OF THE NATURE OF THE CONDUCTOR UPON ITS SELF-INDUCTION.

I found, as shown in my late paper, that there was a marked difference in the specific inductive capacity of iron and copper, and this entirely agrees with well-known theories; but I suspected that there might be some difference in the non-magnetic metals independent of their specific resistance. For this purpose I made a series of experiments with wires of the same length and diameter, but of different resistance. These showed a marked difference provided the current was increased in proportion to its diameter or conductivity, but no difference could be found when the current was kept a constant, and the interior differences in resistance of the wires were compensated by an external added resistance; but if we take wires of different metals—all of the same length and resistance, but of different diameters—there is a marked difference due to the mutual reactions of the current in its own wire, being less in wire of large diameter than in small wires. These effects have been fully explained in my late paper, and have since been completely verified by the method used at

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present. I showed by the use of my late method a critical point in the rise and fall of the induced currents; this is not shown by the present method of compensating by external resistance, but the rapid decrease in the electromotive force of the induced currents, as indicated by the induction balance, is well shown by the present method. The following table shows the observed force of the extra currents for wires of the same length (1 metre), but of different diameters:—

	mm. 0.25	mm. 0.50	mm. 1.00	mm. 2:00	mm. 3.00	mm. 4.00	mm. 5.00	mm. 6.00	mm. 7.00	mm. 8.00	mm. 9.00	mm. 10.00
Iron....	760	621	530	360	269	220	190	171	152	138	128	124
Copper.. ...	129	118	100	89	82	78	75	73	72	71.5	71.2	71

The fall in force is now even more rapid than shown by my late method, and it will be seen that iron is peculiarly sensitive to an increase in diameter, having nearly six times the force of copper in wires of 0.25 mm., and not twice the force of copper in wires of 10 mm. section.

REACTIONS OF AN ELECTRIC CURRENT IN ITS OWN PORTION OF CONDUCTOR.

The phenomenon of a constant decrease in the electromotive force of self-induction, as measured by the induction balance, with each increase of the sectional area of the conductor, is well shown by the present method, and an experimental investigation of its cause has shown that we should not consider a current in a wire as a single element reacting solely upon exterior wires, but that the current acts precisely similar as would an infinite number of independent streamlets of current reacting upon each other in the interior of its own wire similar to their known effects upon exterior wires. My experiments demonstrate this to a degree that leaves no doubt on my mind as to its truth, for according to this view we should be able to reduce the self-induction to a very great extent by employing thin, flat sheets where the outlying portions are at a comparatively great distance from the central portions. This I have experimentally proved to be the fact, but this experiment alone does not show if the reduction of self-induction is due to a different arrangement of the current in sheets as compared with solids. If the reduction is due to the greater separation of the streamlets, then we should be able to reduce this induction in a still greater degree by employing a conductor composed of numerous small copper wires through which the current is equally divided, and which could be separated or brought close together as desired. This proves to be also an experimental fact, for the conductor formed of numerous strands has far less self-induction than a thin sheet when its wires are separated, so that they can no longer react on each other, and surpasses the thin sheet and approaches the value of a circular wire when these wires are brought near together, so that their mutual reactions can approximate those of the numerous streamlets in a solid conductor.

Iron shows a still greater reduction in its self-induction when in the form of thin, flat sheets or numerous small iron wires separated from each other, with the exception that we cannot restore or approach the value of a solid wire by bringing them in close proximity. The reduction of the induced currents by employing thin sheets instead of a wire is so great in iron that we could not account for it on the mere separation of contiguous portions of the same current, but if we assume that the comparatively high force in iron wires is due to the induced circular magnetism, and that this almost disappears in flat sheets, we account for the fact that a thin flat sheet of iron has less inductive capacity than a similar sheet of copper of the same resistance, but of different widths; and if thin strips of copper, brass, lead and german silver are compared with similar iron strips, and their resistance rendered equal by the added resistance in the bridge, no difference is found between iron and the non-magnetic metals, for under these conditions their inductive capacities appear equal.

REACTIONS OF AN ELECTRIC CURRENT BETWEEN SEPARATE PORTIONS OF THE SAME CONDUCTOR.

In order to distinguish two distinct effects I have defined self-induction as the effect produced by an electric current on its own portion of the wire, and mutual induction as the effect of the reactions between separate portions of the wire on each other.

The mutual induction in iron and copper wires is very different in degree, as shown by the following table:—

TABLE I.

Wires, silk-covered, 1 m. in length, 1 mm. in diameter.	Comparative force of the extra currents.	Strips or ribbons, silk-covered, 1 m. in length, 10 cm. wide, 0.1 mm., thick.	Comparative force of the extra currents
Copper wire, in a single close loop, where each side is in close proximity.	18	Copper strip, in a single close loop, where each side is in close proximity.	14
Copper wire, in a single wide circular loop............	100	Copper strip, in a single wide circular loop...............	60
Copper wire, in a coil of 3 cm. diam., having 10 layers in close proximity....	607	Copper strip, in a coil of 3 cm. diam., having ten layers in close proximity....	580
Iron wire (soft), in a single close loop, as above..............	440	Iron strip (soft), in a single close loop, as above..............	16
Iron wire, in a single circular wide loop.	502	Iron strip, in a single circular wide loop.	60
Iron wire, in a coil, as in the case of copper................	570	Iron strip, in a coil, as stated for copper................	578

There is a remarkable fall in the induction of a straight wire or single wide loop of a copper wire when this wire is doubled upon itself as a return wire in close proximity. The effect of mutual induction is also shown by the equally remarkable rise when the mutual induction of ten layers of a coil react on each other. This is well known; but what I believe has not yet been experimentally observed is the remarkably feeble mutual induction of iron wires, either when in parallel return in close proximity or when in coils of numerous layers. The percentage of increase of induction in a copper wire from a wide single loop to that of the ten layers being 507 per cent., whilst in iron under precisely the same conditions there was an increase of but 13.6 per cent.

That this remarkable difference as shown between the mutual induction of iron and copper wires is due entirely to the circular magnetism in the iron wire, and that the mutual reactions of the streamlets of the current in a thin, flat iron conductor prevent this formation I have proved in various ways, for if the circular magnetism is the cause, flat iron sheets which have as low self-induction as copper should be equally sensitive to mutual induction as the non-magnetic metals, for they no longer in any appreciable degree possess the protecting magnetic sheath which enfeebles the mutual reactions of iron wires upon each other; this proves to be the case, a thin ribbon of iron having the same coefficient of mutual induction as copper, and it no longer behaves as a magnetic body.

Table I shows the difference in the mutual induction of iron wires and strips; it will be seen that when the iron is in the form of a wire the circular magnetism produces a marked difference between iron and copper, whilst in the form of flat strips the iron resembles copper (as regards mutual induction) in every respect.

(To be continued.)

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RECKENZAUN'S ELECTRIC MINING LOCOMOTIVE.

ELECTRICITY has for some time been successfully applied in the Trafalgar colleries, Gloucestershire, England, for pumping water, and for ventilating. It is now the intention to use it as a substitute for horses in subterranean haulage, and Mr. A. Reckenzaun has designed a motor for that purpose. Small coal has practically no value at the pit. Although this motor weighs but 402 pounds, it will be observed that the commercial efficiency exceeds 70 per cent. in all cases. It gives at 1,040 revolutions a maximum of 8.85 brake h.p., with an expenditure of 12.32 electrical h.p., that is, one brake h.p. for every 45.4 pounds of material, or one electrical h.p. for 32.6 pounds of iron, copper, &c., at the high efficiency of about 72 per cent. The following tables gives the details of the tests:

RECKENZAUN MOTOR.—TESTS TAKEN MARCH 5TH, 1886.

No. of test.	Revolutions per minute.	Electrical measurements. Volts. Indicated.	Electrical measurements. Volts. Corrected.	Electrical measurements. Current in ampères.	Prony brake. Length of lever in feet.	Prony brake. Weight on scale in lbs.	Electrical energy. Horse-power $\frac{E \times C}{746}$.	Mechanical work. Horse-power measured.	Percentage of return.	Temperature observed. Fahr.	Remarks.
1	1020	104	105	35.5	2.625	7	4.98	3.568	71.65	60°	This motor shows a remarkable uniformity of efficiency through a scale of powers varying from 4.98 to 12.32 h.p. As it will in actual operations have to act under considerably varying conditions, this result is greatly in its favor. In this motor there are only two brushes used (one pair), which were not shifted or adjusted during these tests; these brushes, moreover, are placed in a position so that the direction of rotation of the armature can be effected by merely reversing the direction of the current through the armature. We did not observe any undue sparking at the commutator when the motor was running.
2	1013	106.5	107	40.0	"	8	5.73	4.027	70.50	58°	
3	982	103.75	104.75	39.5	"	8	5.55	3.930	70.8	60°	
4	860	94.75	95.5	43.25	"	9	5.53	3.870	70.0	59°	
5	970	105.5	106.5	43.0	"	9	6.14	4.385	71.4	60°	
6	900	101.0	101.78	46.75	"	10	6.38	4.500	70.5	59°	
7	1022	112.5	113.6	47.0	"	10	7.15	5.110	71.4	61°	
8	1048	114.0	114.88	7 .75	"	10	7.35	5.240	71.3	59°	
9	1047	120.5	121.88	53.0	"	12	8.66	6.282	72.5	61.5°	
10	1070	121.25	122.64	54.0	"	12	8.87	6.420	72.3	61.5°	
11	950	113.0	113.87	62.0	"	14	9.46	6.650	70.3	59°	
12	1040	127.0	127.7	72.0	"	17	12.32	8.85	71.8	58°	

22 PATERNOSTER ROW, LONDON, E. C.,
March 20th, 1886.

Messrs. STEPHENS, SMITH & Co.,
Engineers, Cuba street, Millwall.

Gentlemen—Towards the end of the week, ending March 6th, we tested, in accordance with your instructions, a Reckenzaun electro-motor, manufactured at your works and intended for electrical haulage works at the Trafalgar collieries, Drybrook, Gloucestershire. It is nominally classed as a 4 h.p., and the resistances of its armature and field magnets are, as given to us by Mr. Reckenzaun, 0.2 ohm and 0.16 ohm, respectively. The weight of the motor (inclusive) was 402 lbs.

Electrical energy was supplied to the motor from a number of E. P. S. secondary cells, and the mechanical work returned was ascertained by means of a balanced Prony brake. The difference of potential at the motor terminals and the current were indicated on Ayrton and Perry direct-reading measuring instruments of the latest type. These excellent instruments, very kindly placed at our service by Mr. A. Le Neve Foster, of Messrs. Latimer Clark, Muirhead & Co., were accompanied by certificates of accuracy signed by Professors Ayrton and Perry. The ammeter was certified as being correct on January 11th, and the voltmeter's calibration at 13° C. was guaranteed on the 24th of February, both of the present year.

After our measurements at your works had been completed, the readings of the above instruments were checked by us. The ammeter was found to be accurately adjusted up to 40 ampères, the greatest current we had then at our command. It is, therefore, only just to assume that it was equally accurate in the higher readings.

The voltmeter was checked by us with the following result:

Discharge from Fleming standard cell (1.072 volts) = 209°
" " battery at voltmeter terminals = 201.5

$$E.\ M.\ F. = \frac{1.072 \times 201.5}{209} = 103.3 \text{ volts.}$$

Voltmeter reading = 103 "

Temperature at time of test: $55\frac{1}{2}°$ F. = 13° C., about.

N. B.—At higher temperatures in the new Ayrton and Perry instrument the scale reading must be *increased*, and at lower temperatures *diminished* by 0.388 per cent per degree C.

In the accompanying table we give a fair average of a large number of measurements, each of our tests being repeated at least four times.

In the formula for the Prony brake $\frac{w \times l \times n}{5252}$; w is the weight in lbs., l the length of lever, and n the number of revolutions per minute.

We understand that this is the first electro-motor constructed by your firm; doubtless, with a few slight modifications indicated by experience with this motor, a still higher efficiency will in the future be obtained. It is only fair to say that, owing to the motor having been accidentally splashed by the soap and water lubrication from the Prony brake at a preliminary trial, it is probable that a slight leakage caused a little waste of current. As it is, however, we are unaware of any other construction of electro-motor of similar size, weight and speed, which has shown so high a percentage of return. We are, gentlemen,

Yours truly, H. ALABASTER, GATEHOUSE & Co.

TABLE OF THE PROPERTIES OF COPPER, IRON AND GERMAN SILVER WIRE.

BY CARL HERING.

THE new standard English (or British) gauge having recently been adopted, and the use of the decimal gauge or scale of decimals of an inch, having increased, the writer has calculated the following tables, which give the most important properties for the different sizes of wires of these two gauges, besides those of the American standard or Brown and Sharpe gauge.

Most of the tables heretofore used are incomplete, as they do not contain certain properties which it is frequently found desirable to have in the form of a table. They are generally based on the resistance of chemically pure copper, which is seldom used in practice, thus limiting the use of the table or else necessitating a further reduction. Although they are all based on the resistance of pure copper, its values for the same wire in different tables are not alike. They are all based on the old ohm or B. A. unit, which is now less frequently used, the legal or Paris ohm having been universally adopted. All the tables heretofore published of the American or B. and S. gauge contain incorrect values for certain sizes, owing to some errors which were contained in the original table of sizes of this gauge, from which the diameters are taken.

In the following tables all the values have been based on the same constants, and have been calculated for good commercial copper, such as is generally used in practice. The resistances are all in legal ohms, and are calculated for the mean temperature of 75° Fahrenheit (or 23.889°C.).

Several columns, not usually contained in similar tables,

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have been added here. Among these are the following: the decimal gauge, column 2, and the properties for these sizes; column 5, by means of which the wires may be more readily compared to the sizes in the metric scale; columns 6 and 7, by means of which many calculations are simplified; columns 8, 14, 15, 16, 17 and 18, which will frequently be found of use; columns 15 and 16 are numerically the same as columns 6 and 7 respectively.

At the end of the first table there are a series of values corresponding to the value 1 or unity, for each column, which will often be found useful in certain calculations. In the second table will be found two complete sets of constants, the first giving the numbers by which any of the values in the large table must be multiplied to reduce them to the corresponding values for pure copper, iron or german silver; the second giving the constants by means of which all the properties of different kinds of wire may be calculated directly for any diameter by multiplying or dividing these constants by the square or fourth power of the diameter or cross section of the wire, as indicated by the respective formula. For instance, if it is required to find the weight in pounds per ohm of a number 10 B. and S. german-silver wire, the corresponding value for commercial copper from the large table, namely, 30.77, must be multiplied by the constant for german-silver in the 14th column of the second table, .0797, giving 2.452. Or it may be calculated directly from the diameter by multiplying .00000002274 by the fourth power of the diameter, as shown by the formula at the bottom of the 14th column.

The logarithms accompany many of the numbers which are frequently used in calculations as multipliers.

The diameters of the B. and S. gauge were calculated on the basis that each diameter is .890525 times the preceding (the logarithm of this number is $\bar{1}$. 9496464659), and that the absolute size of No. 0000 is .460000 inches, and that of No. 36 is .005000 inches. These constants were obtained from Messrs. Brown and Sharpe.

The sizes of the decimal gauge were so selected as to give as nearly as possible a regular scale of diameters decreasing in a constant ratio, as in the B. and S. scale, as that seems to be the most rational system for a practical gauge.

The sizes of the English standard were taken from the tables frequently published. As none of these differed in any of the sizes, they were assumed to be correct, since no law seems to exist by which the sizes can be verified.

The value of the legal ohm which is the resistance of a column of pure mercury 1 square millimetre in cross section and 106 centimetres long at 0° C. was taken equal to 1.0112 times the ohm which was formerly used, namely, the B. A. ohm. This is equal to an increase of 1.12 per cent. This value is the one given by Glazebrooke, secretary of the British Association, on the standard ohms certified to by him. The value of the metre was taken equal to 39.370790 inches, and that of the gram equal to 15.43235 grains.

The resistance of pure copper was calculated from the value given by Matthiessen,[1] viz., the resistance of one mile (5,280 feet) of chemically pure copper wire, having a diameter of $\frac{1}{16}$ inch, is 13.59 ohms, at a temperature of 15.5° C. It is assumed that the ohm referred to was the B. A. unit. This, when accurately reduced, gives .016714 B. A. ohms, or .016529 legal ohms, for the resistance at 15.5° C. of one metre of copper wire, having a cross section of one square millimetre.

For the temperature correction the following formula, given by Matthiessen and v. Bose, was used: If the conductivity at 0° is 1, then that at t° C. will be, for pure metals (except iron),

$$1 - .0036701\, t + .000009009\, t^2.$$

The value given above of the resistance, is reduced to conductivity, which is divided by this expression, and then reduced again to resistance. This is evidently equivalent to multiplying the resistance at 15.5° by this expression, which then gives directly the resistance at 0° C. In practice the following simpler formula may be used:

$$R \text{ at } t = R \text{ at } 0° \times (1 + at),$$

in which R is the resistance, t the temperature in centigrade degrees, and a is usually taken equal to .0037 or .0038. The formula previously given for decrease in conductivity is for a rise of 15.5°, equivalent to making a equal to .0037348 in the above formula for resistance, while for 75° Fahrenheit (or 23.889° C), it is equivalent to $a = .0037674$, showing that for most purposes a may be safely taken as equal to .00375. For iron, a may be taken equal to .0046, and for german silver .00044. When t is in Fahrenheit degrees this mean value of a for copper is equal to about .002, which is equal to .2 of one per cent. increase in resistance for every degree Fahrenheit. To reduce from a high to a lower temperature it would be necessary to divide by this expression, but in practice it is generally sufficiently accurate to use the following formula:

$$R \text{ at } 0° = R \text{ at } t° \times (1 - at),$$

in which a has the same value as before. In both of these formulæ R at 0° may be the resistance at any temperature lower than t, in which case t in the formulæ must be replaced by the difference of the two temperatures.

The resistance of one metre of good commercial copper wire having one square millimetre cross section was taken equal to .01763 legal ohms at 75° F., which is 3.523 per cent. higher than that of pure copper at the same temperature. The resistance of a similar wire of iron at the same temperature was taken equal to .10976 legal ohms, and that of a similar german-silver wire equal to .21154 legal ohms. The weights were calculated for the following specific gravities: copper, 8.889; iron, 7.7; and german silver, 8.5.

The following simple formulæ, giving approximate values of some of the properties of wire, will frequently be found useful:

Let R = resistance in legal ohms, at 75° F.
L = length in feet.
d = diameter in mils.
W = weight in pounds.

For good commercial copper:

$$R = 10\,\frac{L}{d^2} \text{ or } L = \frac{Rd^2}{10.}$$

$$L = \frac{330,000}{d^2}\,W.$$

For iron:

$$R = 66\,\frac{L}{d^2} \text{ or } L = .015\,Rd^2.$$

$$L = \frac{400,000\,W}{d^2.}$$

For german silver:

$$R = \frac{1,000}{8}\frac{L}{d^2} \text{ or } L = .008\,Rd^2.$$

$$L = \frac{1,000,000\,W}{3\,d^2.}$$

The resistance of iron is about 6 times that of copper, and that of german silver is about twice that of iron, or 12 times that of copper.

Besides these formulæ many others may be deduced directly from the formulæ in the last part of the table, by substituting an approximate simple number or vulgar fraction for the decimal fractions given there.

1. Report of the British Association Committee on Electrical Standards, 1878.

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TABLE OF THE PROPERTIES OF COMMERCIAL COPPER WIRE, FOR THE AMERICAN STANDARD, ENGLISH STANDARD AND DECIMAL GAUGES, WITH CONSTANTS FOR CALCULATING THE PROPERTIES OF PURE COPPER, COMMERCIAL IRON AND GERMAN-SILVER WIRE.

CALCULATED BY CARL HERING.

Numbers of gauges.			Diameters.		Areas of cross section.		Weights and Lengths; sp. gr. 8.889.			Resistances of soft, good commercial copper, at 75° F. (= 23.89 °C.) in legal ohms; 1 metre of 1 sq. m. m. cross section has .01763 ohms at 75° F.				Current in ampères.		Logarithms.	
American or Brown & Sharpe wire gauge.	Decimal gauge in mils.	New British gauge, March, 1884, or Standard wire gauge.	Diameter in mils, 1 mil = .001 inch.	Diameter in millimetres. 1 m. m. = 39.3708 mils.	Cross section in square mils. (*A*.) 1 sq. in. = 1,000,000 sq. mils.	Cross section in square millimetres. 1 sq. m. m. = 1550.1 sq. mils.	Pounds per mile.	Pounds per 1000 feet.	Feet per pound.	Ohms per 1000 feet (*R*.), or Loss of potential in volts, per ampère per 1000 feet. (*V*.)	Ohms per pound.	Feet per ohm.	Pounds per ohm.	At 1000 ampères per square inch, or .001 ampère per sq. mil.	At 1 ampère per square millimetre.	Logarithm of cross section *A*, in square mils.	Logarithm of resistance *R* and loss of potential *V*.
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
	500.	0000000	500.00	12.700	196350.	126.68	3995.	756.6	1.322	.04242	.0000561	23573.	17836.	196.	127.	5.2930299	$\bar{2}$.62758
		000000	464.00	11.785	169093.	109.09	3440.	651.6	1.535	.04926	.0000756	20301.	13228.	169.	109.	5.2281259	$\bar{2}$.69248
0000			460.00	11.684	166190.	107.22	3381.	640.4	1.562	.05012	.0000783	19953.	12778.	166.	107.	5.2206055	$\bar{2}$.70000
	450.		450.00	11.430	159043.	102.61	3236.	612.9	1.632	.05237	.0000855	19094.	11702.	159.	103.	5.2015149	$\bar{2}$.71910
		00000	432.00	10.972	146574.	94.56	2982.	564.8	1.770	.05683	.0001006	17598.	9939.	147.	94.6	5.1660573	$\bar{2}$.75455
	425.		425.00	10.795	141863.	91.61	2886.	534.2	1.829	.05871	.0001074	17032.	9310.	142.	91.6	5.1518677	$\bar{2}$.76874
000			409.64	10.405	131790.	85.026	2681.	507.9	1.969	.06320	.0001244	15823.	8036.	132.	85.0	5.1198985	$\bar{2}$.80071
	400.	0000	400.00	10.160	125664.	81.07	2557.	484.2	2.065	.06628	.0001369	15087.	7306.	126.	81.1	5.0992099	$\bar{2}$.82140
	375.		375.00	9.525	110450.	71.25	2247.	425.6	2.350	.07542	.0001772	13260.	5643.	110.	71.3	5.0431525	$\bar{2}$.87746
		000	372.00	9.448	108687.	70.12	2211.	418.8	2.388	.07664	.0001830	13049.	5465.	109.	70.1	5.0361757	$\bar{2}$.88443
00			364.80	9.2657	104518.	67.428	2127.	402.8	2.483	.07969	.0001979	12548.	5054.	105.	67.4	5.0191913	$\bar{2}$.90142
	350.		350.00	8.890	96211.	62.07	1958.	370.8	2.697	.08657	.0002335	11551.	4282.	96.2	62.1	4.9832259	$\bar{2}$.93738
		00	348.00	8.839	95115.	61.37	1935.	366.5	2.728	.08757	.0002389	11419.	4185.	95.1	61.4	4.9782483	$\bar{2}$.94236
	325.		325.00	8.255	82958.	53.52	1688.	319.7	3.128	.1004	.0003141	9960.	3184.	83.0	53.7	4.9188567	$\bar{1}$.00175
0			324.86	8.2513	82887.	53.473	1686.	319.4	3.131	.1005	.0003146	9951.	3178.	82.9	53.5	4.9184848	$\bar{1}$.00212
		0	324.00	8.229	82448.	53.19	1677.	317.7	3.148	.1010	.0003180	9899.	3145.	82.4	53.2	4.9161799	$\bar{1}$.00443
	300.	1	300.00	7.620	70686.	45.60	1438.	272.4	3.671	.1178	.0004326	8486.	2312.	70.7	45.6	4.8493325	$\bar{1}$.07128
1			289.30	7.3480	65732.	42.406	1337.	253.3	3.948	.1267	.0005008	7892.	1999.	65.7	42.4	4.8177773	$\bar{1}$.10288
		2	276.00	7.010	59828.	38.59	1217.	230.5	4.338	.1392	.0006039	7183.	1656.	59.8	38.6	4.7769080	$\bar{1}$.14370
	275.		275.00	6.985	59396.	38.32	1208.	228.9	4.369	.1402	.0006127	7131.	1632.	59.4	38.3	4.7737558	$\bar{1}$.14685
2			257.63	6.5436	52128.	33.630	1061.	200.9	4.978	.1598	.0007955	6258.	1257.	52.1	33.6	4.7170701	$\bar{1}$.20354
		3	252.00	6.401	49876.	32.17	1015.	192.2	5.203	.1670	.0008689	5988.	1151.	49.9	32.2	4.6978909	$\bar{1}$.22272
	250.		250.00	6.350	49087.	31.67	998.7	189.2	5.287	.1697	.0008971	5893.	1115.	49.1	31.7	4.6909699	$\bar{1}$.22964
		4	232.00	5.893	42273.	27.27	860.1	162.9	6.139	.1970	.001210	5075.	826.8	42.3	27.3	4.6260659	$\bar{1}$.29454
3			229.42	5.8272	41339.	26.669	841.1	159.3	6.278	.2015	.001265	4963.	790.6	41.3	26.7	4.6163681	$\bar{1}$.30424
	225.		225.00	5.715	39761.	25.65	809.0	153.2	6.527	.2095	.001367	4774.	731.4	39.8	25.6	4.5994549	$\bar{1}$.32116
		5	212.00	5.385	35299.	22.77	718.2	136.0	7.352	.2360	.001735	4238.	576.4	35.3	22.8	4.5477617	$\bar{1}$.37285
4			204.31	5.1893	32784.	21.150	667.0	126.3	7.916	.2541	.002011	3936.	497.2	32.8	21.2	4.5156559	$\bar{1}$.40495
	200.		200.00	5.080	31416.	20.27	639.2	121.1	8.260	.2651	.002190	3772.	456.6	31.4	20.3	4.4971499	$\bar{1}$.42346
		6	192.00	4.877	28953.	18.68	589.1	111.6	8.963	.2877	.002579	3476.	387.8	29.0	18.7	4.4616923	$\bar{1}$.45892
5			181.94	4.6212	25999.	16.773	529.0	100.2	9.982	.3204	.003198	3121.	312.7	26.0	16.8	4.4149489	$\bar{1}$.50566
	180.		180.00	4.572	25447.	16.42	517.7	98.06	10.20	.3273	.003338	3055.	299.6	25.4	16.4	4.4056349	$\bar{1}$.51498
		7	176.00	4.470	24328.	15.69	495.0	93.75	10.67	.3424	.003652	2921.	273.8	24.3	15.7	4.3861153	$\bar{1}$.53449
6			162.02	4.1153	20618.	13.301	419.5	79.45	12.59	.4040	.005085	2475.	196.7	20.6	13.3	4.3142419	$\bar{1}$.60637
	160.	8	160.00	4.064	20106.	12.97	409.1	77.48	12.91	.4143	.005347	2414.	187.0	20.1	13.0	4.3033299	$\bar{1}$.61728
7			144.29	3.6648	16351.	10.548	332.7	63.01	15.87	.5094	.008085	1963.	123.7	16.4	10.5	4.2135349	$\bar{1}$.70707
		9	144.00	3.658	16286.	10.51	331.3	62.76	15.93	.5114	.008150	1955.	122.7	16.3	10.5	4.2118149	$\bar{1}$.70880
	140.		140.00	3.556	15394.	9.931	313.2	59.32	16.86	.5411	.009121	1848.	109.6	15.4	9.93	4.1873459	$\bar{1}$.73326
	130.		130.00	3.302	13273.	8.563	270.1	51.15	19.55	.6275	.01227	1594.	81.51	13.3	8.56	4.1229767	$\bar{1}$.79763
8			128.49	3.2636	12967.	8.3658	263.8	49.97	20.01	.6424	.01286	1557.	77.79	13.0	8.37	4.1128279	$\bar{1}$.80778
		10	128.00	3.251	12868.	8.302	261.8	49.59	20.17	.6478	.01305	1545.	76.60	12.9	8.30	4.1095099	$\bar{1}$.81110
	120.		120.00	3.048	11310.	7.296	230.1	43.58	22.95	.7365	.01690	1358.	59.18	11.3	7.40	4.0534523	$\bar{1}$.86716
		11	116.00	2.946	10568.	6.818	215.0	40.73	24.67	.7881	.01935	1269.	51.67	10.6	6.82	4.0240059	$\bar{1}$.89660
9			114.42	2.9063	10283.	6.6339	209.2	39.63	25.24	.8100	.02044	1235.	48.92	10.3	6.63	4.0121207	$\bar{1}$.90849
	110.		110.00	2.794	9503.	6.067	193.4	36.62	27.31	.8765	.02393	1141.	41.78	9.50	6.09	3.9778753	$\bar{1}$.94273
		12	104.00	2.642	8495.	5.480	172.8	32.73	30.55	.9805	.02995	1020.	33.39	8.50	5.48	3.9291565	$\bar{1}$.99145
10			101.90	2.5881	8154.8	5.2610	165.9	31.42	31.82	1.021	.03250	979.1	30.77	8.15	5.26	3.9114137	0.00919
	100.		100.00	2.540	7854.	5.067	159.8	30.27	33.04	1.061	.03504	942.9	28.54	7.85	5.07	3.8950899	0.02552
		13	92.000	2.337	6648.	4.289	135.3	25.62	39.04	1.253	.04891	798.1	20.44	6.65	4.29	3.8226655	0.09794
11			90.742	2.3048	6467.0	4.1721	131.6	24.92	40.13	1.288	.05168	776.4	19.35	6.47	4.17	3.8107065	0.10990
	90.		90.000	2.286	6362.	4.104	129.4	24.51	40.79	1.309	.05341	763.8	18.72	6.36	4.10	3.8035749	0.11704
12			80.808	2.0525	5128.6	3.3087	104.4	19.76	50.60	1.624	.08218	615.7	12.17	5.13	3.31	3.7099995	0.21061
	80.	14	80.000	2.032	5027.	3.243	102.3	19.37	51.63	1.657	.08555	603.5	11.69	5.03	3.24	3.7012699	0.21934
		15	72.000	1.829	4072.	2.627	82.84	15.69	63.74	2.046	.1304	488.8	7.669	4.07	2.63	3.6097549	0.31086
13			71.962	1.8278	4067.2	2.6239	82.75	15.67	63.81	2.048	.1307	488.3	7.653	4.06	2.62	3.6092925	0.31132
	70.		70.000	1.778	3848.	2.483	78.30	14.83	67.43	2.164	.1459	462.0	6.852	3.85	2.48	3.5852859	0.33532
14			64.084	1.6277	3225.4	2.0808	56.08	12.43	80.46	2.582	.2078	387.2	4.818	32.3	2.08	3.5085858	0.41202
		16	64.000	1.626	3217.	2.076	65.45	12.40	80.67	2.589	.2084	386.2	4.788	3.22	2.07	3.5074499	0.41316
	60.		60.000	1.524	2827.	1.824	57.58	10.90	91.78	2.946	.2704	339.5	3.698	2.83	1.82	3.4513925	0.46922
15			57.068	1.4495	2557.9	1.6502	52.20	9.857	101.5	3.256	.3304	307.1	3.027	2.56	1.65	3.4078783	0.51273
		17	56.000	1.422	2463.	1.589	50.11	9.491	105.4	3.382	.3646	295.7	2.807	2.46	1.59	3.3914659	0.52914
16			50.821	1.2908	2028.5	1.3086	41.27	7.817	127.9	4.106	.5253	243.5	1.904	2.03	1.31	3.3071711	0.61344
	50.		50.000	1.270	1964.	1.267	39.95	7.566	132.2	4.242	.5607	235.7	1.784	1.96	1.27	3.2930299	0.62758
		18	48.000	1.219	1810.	1.167	36.82	6.973	143.4	4.603	.6601	217.3	1.515	1.81	1.17	3.2575728	0.66304
17			45.257	1.1495	1608.7	1.0378	32.73	6.199	161.3	5.178	.8353	193.1	1.197	1.61	1.04	3.2064641	0.71414
	45.		45.000	1.143	1590.	1.026	32.36	6.129	163.2	5.237	.8545	190.9	1.170	1.59	1.03	3.2015149	0.71910
18			40.303	1.0237	1275.7	.82302	25.96	4.916	203.4	6.529	1.325	153.2	.7529	1.28	.823	3.1057571	0.81485
	40.	19	40.000	1.016	1257.	.8107	25.57	4.842	206.5	6.628	1.369	150.9	.7306	1.26	.811	3.0992099	0.82140
		20	36.000	.9144	1018.	.6567	20.71	3.922	255.0	8.183	2.086	122.2	.4793	1.02	.657	3.0076949	0.91292
19			35.891	.91160	1011.7	.65268	20.58	3.899	256.5	8.233	2.112	121.5	.4735	1.01	.653	3.0050499	0.91556
	35.		35.000	.8890	962.1	.6207	19.58	3.708	269.7	8.657	2.335	115.5	.4282	.962	.621	2.9832259	0.93738
		21	32.000	.8128	804.2	.5188	16.36	3.099	322.7	10.36	3.342	96.56	.2992	.804	.519	2.9053899	1.01522
20			31.961	.81181	802.31	.51760	16.32	3.092	323.5	10.38	3.358	96.33	.2978	.802	.518	2.9043429	1.01626
	30.		30.000	.7620	706.9	.4560	14.38	2.724	367.1	11.78	4.326	84.86	.2312	.707	.456	2.8493325	1.07128
21			28.462	.72298	636.26	.41048	12.95	2.452	407.9	13.09	5.389	76.39	.1873	.636	.410	2.8036357	1.11697

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TABLE OF THE PROPERTIES OF COMMERCIAL COPPER WIRE, &c.

(Continued.)

Numbers of gauges.			Diameters.		Areas of cross section.		Weights and Lengths; sp. gr. 8.889.			Resistances of soft, good commercial copper at 75° F. (= 23.89° C.) in legal ohms; 1 metre of 1 sq. m. m. cross section has .01763 ohms at 75° F.				Current in ampères.		Logarithms.	
American or Brown & Sharpe wire gauge.	Decimal gauge in mils.	New British gauge, March, 1884, or Standard wire gauge.	Diameter in mils. 1 mil = .001 inch.	Diameter in millimetres. 1 m. m. = 39.3708 mils.	Cross section in square mils. (*A*.) 1 sq. in. = 1,000,000 sq. mils.	Cross section in square millimetres. 1 sq. m. m. = 1550.1 sq. mils.	Pounds per mile.	Pounds per 1000 feet.	Feet per pound.	Ohms per 1000 feet (*R*.), or Loss of potential in volts, per ampère per 1000 feet. (*V*.)	Ohms per pound.	Feet per ohm.	Pounds per ohm.	At 1000 ampères per square inch, or, .001 ampère per sq. mil.	At 1 ampère per square millimetre.	Logarithm of cross section *A*, in square mils.	Logarithm of resistance *R* and loss of potential *V*.
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
	28.	22	28.000	.7112	615.8	.3972	12.53	2.373	421.4	13.53	5.701	73.93	.1754	.616	.397	2.7894059	1.13120
	26.		26.000	.6604	530.9	.3425	10.80	2.046	488.6	15.69	7.668	63.74	.1304	.531	.343	2.7250365	1.19557
22			25.347	.64379	504.58	.32552	10.27	1.944	514.3	16.51	8.490	60.58	.1178	.505	.326	2.7029287	1.21768
	24.	23	24.000	.6096	452.4	.2919	9.204	1.743	573.6	18.41	10.56	54.31	.09468	.452	.292	2,6555123	1.26510
23			22.572	.57331	400.15	.25815	8.141	1.542	648.5	20.82	13.50	48.04	.07408	.400	.258	2.6022217	1.31839
	22.	24	22.000	.5588	380.1	.2452	7.734	1.465	682.7	21.91	14.96	45.64	.06685	.380	.245	2.5799858	1.34067
24			20.101	.51055	317.33	.20472	6.456	1.223	817.8	26.25	21.47	38.10	.04659	.317	.205	2.5015145	1.41909
	20.	25	20.000	.5080	314.2	.2027	6.392	1.211	826.0	26.51	21.90	37.72	.04566	.314	.203	2,4971499	1.42346
	18.	26	18.000	.4572	254.5	.1642	5.177	.9806	1020.	32.73	33.38	30.55	.02996	.255	.164	2.4056349	1.51498
25			17.900	.45466	251.66	.16235	5.120	.9697	1031.	33.10	34.13	30.21	.02930	.252	.162	2.4008075	1.51980
		27	16.400	.4166	211.2	.1363	4.298	.8140	1229.	39.43	48.44	25.36	.02064	.211	.136	2.3247775	1.59583
	16.		16.000	.4064	201.1	.1297	4.091	.7748	1291.	41.43	53.47	24.14	.01870	.201	.130	2.3033299	1.61728
26			15.941	.40488	199.57	.12875	4.061	.7690	1300.	41.74	54.27	23.96	.01843	.200	.129	2.3001005	1.62051
	15.		15.000	.3810	176.7	.1140	3.595	.6810	1468.	47.13	69.22	21.22	.01445	.177	.114	2.2472725	1.67334
		28	14.800	.3759	172.0	.1110	3.500	.6629	1508.	48.42	73.04	20.65	.01369	.172	.111	2.2356133	1.68500
27			14.196	.36056	158.27	.10211	3.220	.6099	1640.	52.63	86.29	19.00	.01159	.158	.102	2.1993985	1.72121
	14.		14.000	.3556	153.9	.09931	3.132	.5932	1686.	54.11	91.21	18.48	.01096	.154	.099	2.1873459	1.73326
		29	13.600	.3454	145.3	.09372	2.956	.5598	1786.	57.34	102.4	17.44	.009763	.145	.094	2.1621677	1.75844
	13.		13.000	.3302	132.7	.08563	2.701	.5115	1955.	62.75	122.7	15.94	.008151	.133	.086	2.1229767	1.79763
28			12.641	.32109	125.51	.08097	2.554	.4836	2068.	66.36	137.2	15.07	.007288	.126	.081	2.0986863	1.82194
		30	12.400	.3150	120.8	.07793	2.457	.4654	2149.	68.97	148.2	14.50	.006747	.121	.078	2.0819333	1.83868
	12.		12.000	.3048	113.1	.07296	2.301	.4358	2295.	73.65	169.0	13.58	.005918	.118	.073	2.0534523	1.86716
		31	11.600	.2946	105.68	.06818	2.150	.4073	2456.	78.81	193.5	12.69	.005167	.106	.068	2.0240059	1.89660
29			11.258	.28594	99.535	.06421	2.025	.3836	2607.	83.68	218.2	11.95	.004584	.100	.064	1.9979798	1.92263
	11.		11.000	.2794	95.03	.06087	1.934	.3662	2731.	87.65	239.3	11.41	.004178	.095	.061	1.9778753	1.94278
		32	10.800	.2743	91.61	.05910	1.864	.3530	2833.	90.92	257.6	11.00	.003883	.092	.059	1.9619375	1.95867
30			10.025	.25463	78.935	.05092	1.606	.3042	3288.	105.5	346.9	9.477	.002883	.079	.051	1.8972723	2.02334
	10.	33	**10.000**	.2540	78.54	.05067	1.598	.3027	3304.	106.1	350.4	9.429	.002854	.079	.051	1.8950899	2.02552
		34	9.2000	.2337	66.48	.04289	1.353	.2562	3904.	125.3	489.1	7.981	.002044	.066	.043	1.8226655	2.09794
	9.		9.0000	.2286	63.62	.04104	1.294	.2451	4079.	130.9	534.1	7.638	.001872	.064	.041	1.8035749	2.11704
31			8.9277	.22675	62.599	.04039	1.274	.2412	4146.	133.1	551.6	7.515	.001813	.063	.0404	1.7965651	2.12404
		35	8.4000	.2134	55.42	.03575	1.127	.2136	4683.	150.3	703.8	6.653	.001421	.055	.0358	1.7436485	2.17696
	8.		8.0000	.2032	50.27	.03243	1.023	.1937	5163.	165.7	855.5	6.035	.001169	.050	.032	1.7012699	2.21934
32			7.9503	.20193	49.643	.03203	1.010	.1913	5228.	167.8	877.1	5.960	.001140	.050	.032	1.6958581	2.22475
		36	7.6000	.1930	45.36	.02926	.9230	.1748	5720.	183.6	1050.	5.446	.0009521	.045	.029	1.6567171	2.26389
33			7.0800	.17983	39.369	.02539	.8010	.1517	6592.	211.6	1395.	4.727	.0007170	.039	.025	1.5951511	2.32546
	7.		7.0000	.1778	38.48	.02483	.7830	.1483	6743.	216.4	1459.	4.620	.0006852	.038	.025	1.5852859	2.33532
		37	6.8000	.1727	36.32	02343	.7389	.1399	7146.	224.1	1639.	4.360	.0006102	.036	.023	1.5601077	2.36050
34			6.3049	.16014	31.221	.02014	.6352	.1203	8312.	266.8	2218.	3.748	.0004510	.031	.020	1.4944439	2.42616
	6.	38	6.0000	.1524	28.27	.01824	.5753	.1090	9178.	294.6	2704.	3.395	.0003698	.028	.018	1.4513925	2.46922
35			5.6147	.14261	24.759	.01597	.5038	.09541	10482.	336.4	3526.	2.973	.0002836	.024	.016	1.3937869	2.52687
		39	5.2000	.1321	21.24	.01370	.4321	.08184	12220.	392.2	4792.	2.550	.0002087	.021	.014	1.3270965	2.59351
36	5.		5.0000	.12700	19.635	.01267	.3995	.07566	13217.	424.2	5607.	2.357	.0001784	.020	.013	1.2930299	2.62758
		40	4.8000	.1219	18.10	.01167	.3682	06973	14341.	460.3	6601.	2.173	.0001515	.018	.012	1.2575728	2.66804
37			4.4526	.11309	15.571	.010046	.3168	.06000	16666.	534.9	8915.	1.869	.0001122	.016	.010	1.1923229	2.72828
		41	4.4000	.1117	15.21	.009809	.3023	.05859	17067.	547.8	9349.	1.826	.0001070	.015	.0098	1.1819953	2.73861
	4.	42	4.0000	.1016	12.57	.008107	.2557	.04842	20651.	662.8	13688.	1.509	.0000731	.013	.0081	1.0992099	2.82140
38			3.9652	.10071	12.349	.007967	.2512	.04758	21015.	674.5	14175.	1.483	.0000706	.012	.0080	1.0916157	2.82899
		43	3.6000	.0914	10.179	.006561	.2071	.03922	25495.	818.3	20863.	1.222	.0000479	.010	.0066	1.0076949	2.91292
39			3.5311	.08969	9.7928	.006318	.1992	.03774	26500.	850.6	22540.	1.176	.0000444	.0098	.0063	0.9909087	2.92970
		44	3.2000	.0813	8.042	.005191	.1636	.03099	32267.	1036.	33418.	.9656	.0000299	.0080	.0052	0.9053899	3.01522
40			3.1445	.07987	7.7661	.005010	.1580	.02993	33416.	1073.	35841.	.9324	.0000279	.0078	.0050	0.8902017	3.03041
	3.		3.0000	.0762	7.069	.004560	.1438	.02724	36713.	1178.	43260.	.8486	.0000231	.0071	.0046	0.8493325	3.07128
		45	2.8000	.0711	6.158	.003972	.1253	.02378	42146.	1353.	57009.	.7393	.0000175	.0062	.0040	0.7894059	3.13120
		46	2.4000	.0610	4.524	.002918	.09204	.01743	57364.	1841.	105620.	.5431	.0000095	.0045	.0029	0.6555123	3.26510
	2.	47	2.0000	.0508	3.142	.002027	.06392	.01211	82604.	2651.	219010.	.3772	.0000046	.0031	.0020	0.4971499	3.42346
		48	1.6000	.0406	2.011	.001297	.04091	.00775	129068.	4143.	534690.	.2414	.0000019	.0020	.0013	0.3033299	3.61728
		49	1.2000	.0305	1.131	.000730	.02301	.00436	229456.	7365.	1689900.	.1358	.0000006	.0011	.0007	0.0534523	3.86716
	1.	50	**1.0000**	.0254	.7854	.000507	.01598	.00303	330416.	10605.	3504100.	.0943	.0000003	.0008	.0005	$\bar{1}$.8950899	4.02552
			39.371	**1.000**	1217.4	.7854	20.35	4.6912	213.17	6.8418	1 4584	146.16	.68567	1.22	.785	3.0854381	0.83517
			35.682	.90632	**1000.**	64.514	24.77	3.8534	259.510	8.3293	2.1615	120.06	.46263	1.00	.645	3.0000000	0.92061
			44.425	1.1284	1550.1	**1.000**	31.54	5.9730	167.42	5.3735	1.1116	186.10	.89963	1.55	1.00	3.1903482	0.73026
			7.9107	.20093	49.150	.031708	**1.000**	.18939	5280.0	169.47	894.79	5.9008	.001118	.049	.032	1.6915203	2.22909
			18.177	.46170	259.51	.16742	5.280	**1.000**	1000.	32.096	32.096	31.156	.031156	.260	.167	2.4141542	1.50645
			574.82	14.600	259510.	167.42	5280.	1000.	**1.000**	.032096	.0000321	31156.	31156.	260.	167.	5.4141542	$\bar{1}$.50645
			102.98	2.6157	8329.3	5.3735	169.47	32.096	31.156	**1.000**	.031156	1000.	32.096	8.33	5.37	3.9206076	0.00000
			43.266	1.0989	1470.2	.94849	29.913	5.6653	176.51	5.6653	**1.000**	176.51	1.000	.147	.948	3.1673809	0.75323
			3.2566	.08272	8.3293	.005374	.16947	.03210	31156.	1000.	31156.	**1.000**	.0000321	.0083	.0054	0.9206076	3.00000
			43.266	1.0989	1470.2	.94849	29.913	5.6653	176.51	5.6653	1.000	176.51	**1.000**	.147	.948	3.1673809	0.75323

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TABLE OF CONSTANTS FOR CALCULATING THE PROPERTIES OF PURE COPPER, COMMERCIAL IRON AND GERMAN-SILVER WIRES.

For the following materials, multiply any of the figures in the respective columns of the preceding table by these constants.

Kind of wire.	Weights and Lengths.			Resistance.				Current in ampères		Logarithms.	
	Pounds per mile.	Pounds per 1000 feet.	Feet per pound.	Ohms per 1000 feet, (R), or loss of potential in volts per ampère per 1000 feet, (V).	Ohms per pound.	Feet per ohm.	Pounds per ohm.	At 1000 ampères per square inch or .001 ampères per square mil.	At 1 ampère per square millimetre.	Log. of area of cross section a in square mils.	Log. of resistance R and loss of potential V.
No. of columns.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
For pure copper wire at 75° F.	1	1	1	.96596 log. $\bar{1}$.9849594	.96596 log. $\bar{1}$.9849594	1.0352 log. 0.0150406	1.0352 log. 0.0150406	Same as before.	Same as before.	Same as before.	add log. $\bar{1}$.98496
For pure copper wire at 0° C.	1	1	1	.88624 log. $\bar{1}$.9475513	.88624 log. $\bar{1}$.9475513	1.1284 log. 0.0524487	1.1284 log. 0.0524487				add log. $\bar{1}$.94755
For iron wire at 75° F.	.86624 log $\bar{1}$.9376378	.86624 log. $\bar{1}$.9376378	1.1544 log. 0.0623622	6.2258 log. 0.7941983	7.1872 log. 0.8565605	.16062 log. $\bar{1}$.2058017	.13914 log. $\bar{1}$.1434395				add log. 0.79420
For german silver wire at 75° F.	.95624 log $\bar{1}$.9805660	.95624 log. $\bar{1}$.9805660	1.0458 log. 0.0194340	11.909 log. 1.0791843	12.548 log. 1.0985683	.083342 log. $\bar{2}$.9208657	.079695 log. $\bar{2}$.9014317				add log. 1.07913

For any diameter (d) in mils, or area (a) in square mils, not given in the above table, the resistance, weights, etc. can be calculated as follows:

Kind of wire.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
Soft, good commercial copper at 75° (same as table.)	.015980 × d^2 log. $\bar{2}$.2035696 .020346 × a log. $\bar{2}$.3084797	.0030265 × d^2 log. $\bar{3}$.4809357 .0038534 × a log. $\bar{3}$.5858458	330420. ÷ d^2 log. 5.5190643 259510. ÷ a log. 5.4141542	10605. ÷ d^2 log. 4.0255177 8329.3 ÷ a log. 3.9206076	3504100. ÷ d^4 log. 6.5445820 2161500. ÷ a^2 log. 6.3347618	.094294 × d^2 log. $\bar{2}$.9744823 .12006 × a log. $\bar{1}$.0793924	.00000028538 × d^4 log. $\bar{7}$.4554180 .00000046263 × a^2 log. $\bar{7}$.6652382	d^2 × .0007854 log. $\bar{4}$.8950899 a × .001	d^2 × .00050669 log. $\bar{4}$.7047417 a × .00064514 log. $\bar{4}$.8096518	2 log. d + $\bar{4}$.8950899	4.02552—2 log. d 3.92061—log. a
Pure copper at 75° F.	ditto	ditto	ditto	10244 ÷ d^2 log. 4.0104771 8045.8 ÷ a log. 3.9055670	3384900. ÷ d^4 log. 6.5295414 2088000. ÷ a^2 log. 6.3197212	.097616 × d^2 log. $\bar{2}$.9895229 .12429 × a log. $\bar{1}$.0944330	.00000029543 × d^4 log. $\bar{7}$.4704586 .00000047894 × a^2 log. $\bar{7}$.6802788				4.01048—2 log d 3.90557—log. a
Pure copper at 0° C.	ditto	ditto	ditto	9398.7 ÷ d^2 log. 3.9730690 7381.7 ÷ a log. 3.8681589	3105500. ÷ d^4 log. 6.4921333 1915600. ÷ a^2 log. 6.2823131	.10640 × d^2 log. $\bar{1}$.0269310 .13547 × a log. $\bar{1}$.1318411	.00000032201 × d^4 log. $\bar{7}$.5078667 .00000052202 × a^2 log. $\bar{7}$.7176869				3.97307—2 log. d 3.86816—log. a
Iron wire at 75° F.	.013842 × d^2 log. $\bar{2}$.1412074 .017625 × a log. $\bar{2}$.2461175	.0026216 × d^2 log. $\bar{3}$.4185735 .0033380 × a log. $\bar{3}$.5234836	381440. ÷ d^2 log. 5.5814265 299580. ÷ a log. 5.4765164	66026. ÷ d^2 log. 4.8197160 51857. ÷ a log. 4.7148059	25185000. ÷ d^4 log. 7.4011425 15535000. ÷ a^2 log. 7.1913223	.015146 × d^2 log. $\bar{2}$.1802840 .019284 × a log. $\bar{2}$.2851941	.000000039706 × d^4 .log. $\bar{8}$.5988575 .000000064369 × a^2 log. $\bar{8}$.8086777				4.81972—2 log. d 4.71481—log. a
German-silver wire at 75° F.	.015280 × d^2 log. $\bar{2}$.1841356 .019456 × a log. $\bar{2}$ .2890457	.0028940 × d^2 log. $\bar{3}$.4615017 .0036848 × a log. $\bar{3}$.5664118	345540. ÷ d^2 log. 5.5384983 271390. ÷ a log. 5.4335882	127250. ÷ d^2 log. 5.1046520 99941. ÷ a log. 4.9997419	43969000. ÷ d^4 log. 7.6431503 27123000. ÷ a^2 log. 7.4333301	.0078587 × d^2 log. $\bar{3}$.8953480 .010006 × a log. $\bar{2}$.0002581	.00000022743 × d^4 log. $\bar{8}$.3568497 .00000003687 × a^2 log. $\bar{8}$.5666699				5.10465—2 log. d 4.99974—log. a

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ELECTRIC RAILWAY AT MINNEAPOLIS, MINN.

BY C. J. VAN DEPOELE.

MINNEAPOLIS, with its phenomenal growth, has for the past few years felt the necessity of rapid transit to transport its people from the city to the suburbs, where cheaper homes and more comfort can be obtained by the multitude.

The object was accomplished by railroad cars propelled by 75 and 80 h. p. steam dummies, the latter coming down into the heart of the city with trains packed full. Of late, however, the residents along the streets where the railway passes, and the public in general, have proclaimed the steam dummy a nuisance and have succeeded in stopping its entrance into the dense part of the city, so that in order to accommodate the travelling public, some means, other than direct steam power or horse flesh, had to be resorted to.

After some figuring, the Minneapolis, Lyndale and Minnetonka Railway Company entered into a contract with the Van Depoele Electric Manufacturing Company, of Chicago, to bring the trains into the city by means of their electric motors. The trains consist of three or four passenger cars, each weighing eleven tons empty. The number of passengers carried is often as high as 600 at one time, so that the weight of the train is as follows:

Four cars, each eleven tons	44 tons
Six hundred passengers, at 130 lbs	39 tons
Motor cars	8 tons
Total	91 tons

The cars are the same as those used on the New York Elevated Railway. The steam dummy brings the train as far as permitted by the city ordinance, and then the electric motor brings the train down town with its passengers, and as soon as the cars are emptied, the waiting throng rushes in, and in less than a minute the train is moving towards the dummy, there to deliver its cars and to receive an incoming train to be brought down.

This operation of the electric motor begins at six o'clock in the morning, and closes at half-past eleven at night. The distance over which the electric motor travels is at present about a mile; the speed being about seventeen miles an hour; this being the regulation rate within the city limits. Considering the constant stopping and starting at each block, the grades in the road, and the heavy trains, the electric motor must be given the credit of doing at least as good work as could be expected from any steam engine. During the seventeen or eighteen hours of

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service, not a single minute of stoppage is made excepting to let off or take on passengers. This electric road has been in operation for several weeks without a hitch or a breakage. The electric motor, which is of about 40 h. p., works as perfectly under a heavy as under a light load. The electric generator furnishing current to the motor is driven by a 12″ x 18″ cylinder, slide valve engine, making 125 revolutions per minute; steam pressure 60 or 80 lbs. Consumption of coal in 18 hours' run 3,000 lbs.

From the permanency and the character of the work done by this electric railway, it must be admitted that electric motors on elevated as well as ordinary roads will become facts in the immediate future. There is no more trouble in building 200 or 300 h. p. generators than in producing machines of 50 h. p. Several of these machines can be connected up and run in perfect unison, and by uniting their currents, any amount of power can be transmitted with at least as much reliability as from a steam boiler.

Electric motors and generators are, and can be constructed to-day, which will outlast any steam engine, and from the very nature of these machines it becomes possible to use less expert attendance than in the case of a steam locomotive; the parts being fewer and less liable to get out of order on an electric motor than on any other kind of motor, it must and will become the favorite of the industrial world. The public are gradually losing their skepticism, and what had been proclaimed an impossibility yesterday, becomes a fact to-day.

With regard to economy of electrical transmission, it has been shown by Marcel Deprez and others that a mechanical efficiency of over 50% is easily obtained, so that by the use of stationary engines and boilers where cheap fuel can be used the production of electric currents and application leave very little to be desired to make the electric railway system at once practical and economical. The cost of fuel used on a steam locomotive, as compared to a stationary engine, has been discussed too often to be entered upon here, and everybody is well acquainted with the facts.

CORRESPONDENCE.

NEW YORK AND VICINITY.

The Western Union Passes its Quarterly Dividend.—The Meucci Telephone Co. in Trouble.—The New York Electric Club.—Something About the Quotation Service.—Narrow Escape of a Western Union Lineman.—The Tesla Electric Light at Rahway, N. J.

THE passing of the last quarterly dividend of the Western Union Telegraph Co., due July 1, brings us face to face with the stern facts of competition. There can be little question that the affairs of the company are economically managed, but whether all of the measures adopted are productive of the best results is not so certain. It is of course not expected that any of its competitors are paying dividends. This is not a desirable state of affairs, and it shows that even our largest corporations are not exempt from that very common experience of their employés, of not having money enough to meet all the demands upon them on pay-day.

The Meucci Telephone Co. which had made quite extensive preparations in New Jersey for engaging in the telephone business, has been brought to a standstill by the serving upon it at Elizabeth of papers, requiring the company to show cause why it should not be enjoined from introducing telephones. The answer is returnable on June 25th before Judge Nixon, in the United States District Court at Trenton. Meanwhile, the subscribers to the new system, have been notified not to use their telephones. The managers of the Meucci company will contest this action which has been brought against them by the American Bell Telephone Co. of Boston. The local company in New Jersey is not directly interested in the suit.

The New York Electric Club has perfected its organization, issued its constitution and by-laws, and has made arrangements with the new management of French's hotel, on Park Row, by which a special dining room is set apart for the use of its members every day between the hours of 12 and 3 30. This is a most important step in bringing the electrical fraternity into closer social relations, and is receiving flattering encouragement in the shape of applications for membership.

It was stated in these columns in the April issue, that the speed of the Scott and Field printers, used respectively by the Gold and Stock, and Commercial Telegram companies, was now so nearly equal that the relative rapidity of transmission depends more upon the skill of the operator than was formerly the case. This statement did not give the exact facts although derived from an impartial source. The Scott printer is admitted to be the fastest, but in an ordinary market the time consumed in printing a quotation on either system is so short, that the transmitting operator who starts first is usually ahead at the finish. In the closing quotations sent after 3 P. M., however, the volume of work keeps both systems fully occupied for several minutes, and in these cases the Scott printer comes out ahead.

The various branches of the quotation service are gradually increasing, and in some of them rival companies are engaged, so that this field continues to be one of growing importance. Recently the New York Stock Quotation Co. and the Electrical Bulletin Co. have entered into the distribution of sporting and general news, a line of business which has been very thoroughly developed by Hon. John J. Kiernan. It is reported that a gilt-edged fast stock service is being organized for the special use of members of the stock exchange. There does not appear to be very much margin for improvement, but a few seconds of time appear to be worth more in the stock exchange than most people imagine.

James Castle, a lineman in the employ of the Western Union Telegraph Co., was working near the top of one of the tall telegraph poles on 125th street, near Third avenue, June 9, when the cross-arm on which he stood broke in the middle and he fell head first. He threw out his hands and grasped one of the wires, while his right knee hooked over another, and he hung, face down, thirty-five feet from the side walk, with his body swaying to and fro. There were other wires about him, but he could not reach any of them. His cries for assistance brought a large crowd around the pole, but no one could render him the least relief.

Meantime word had been carried to the house of hook and ladder No. 14, 125th street and Fourth avenue, and messengers had been sent to summon other linemen who were working some distance away. Soon Lyman Fitzgerald and John Evoy, two of the linemen, arrived, and Fitzgerald seizing a piece of stout rope, both men hastened up the pole just as the hook and ladder company rattled down the street. By the time the linemen reached the cross-arms a forty-foot ladder had been reared against the pole. A crowd of a thousand or more people had gathered at the scene.

All this took but a few minutes' time, but it must have seemed an eternity to poor Castle, who hung with a death grip to his slender support, while every moment he grew weaker. When Fitzgerald had made his own position secure he made a lasso of the rope and skilfully threw the loop over Castle's shoulders and tightened it. When the rope was passed over the top cross-arm and drawn taut Castle was safe. When this was apparent to the multitude below a great cheer rent the air and was continued for some time. Even when his immediate safety was assured it was still a difficult and dangerous task to get him to the ground, but it was successfully accomplished, with the aid of the firemen. It was found that he was so badly strained and bruised that it was necessary to send him to the hospital.

Rahway, N. J., has accepted a proposition from the Tesla Electric Light Co. to establish 35 lamps for street illumination at the rate of $75, each per year. This is certainly a very low price, but the company is understood to be a local affair, and is doubtless anxious to obtain a foothold to show the value of the Tesla system.

NEW YORK, June 16, 1886.

PHILADELPHIA.

Various Electrical Schemes Before Councils.—The Antagonism to Overhead Wires.—The Bell Company Obtaining more Injunctions.—Village Electric Lighting in the Suburbs.—Electric Train Lighting.—Electric Lights for Girard College.

ELECTRICAL matters in councils here are quite lively. As our city fathers will soon adjourn for their summer vacations, the electricians are hurrying their little or *big* schemes through as rapidly as possible. This is as it should be—"Make hay while the sun shines."

The sub-committee of councils, which had under consideration the general ordinance regulating the laying and construction of underground wires, cables, conductors, tubes, etc., in the city of Philadelphia, reported it to the Electrical Committee on the 15th, with a favorable recommendation. Mr. Hoffman moved to amend by increasing the amount of the bond to be given, binding the companies; taking advantage of the ordinance to pave the streets and keep them in repair for five years, from $5,000 to $10,000.

Mr. Lawson said he thought that $5,000 would be quite sufficient, because the work would be done under the supervision of the chief of the electrical department

Though Mr. McMullen argued the companies were all rich and might give $20,000 as easily as a smaller sum, the amendment was rejected and the report of the sub-committee adopted.

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The sub-committee reported favorably the ordinance granting the Electrical Pneumatic Transit Company permission to lay tubes. The wires are to be laid on Library street to Fourth, to Spruce, to Walnut, to the Delaware; on Walnut street to Fifteenth; on Fifteenth street, from Carpenter street to Fairmount avenue; on Market street, from Fifteenth street to the Schuylkill, and on Fourth street, from Library to Callowhill. A representative of the company said work would be begun as soon as permission would be granted, in the view of finishing the work during the summer. The report was received.

The ordinance granting permission to the Keystone Light and Power Company to lay underground electric light wires in all the streets in the city received favorable recommendation.

The ordinance granting the Philadelphia Time Telegraph Company permission to erect an overhead metallic circuit, inclosing the territory bounded by Walnut and Market streets and Fifth street and the Delaware, was unfavorably reported by the sub-committee. The company is intended to furnish the correct time to all offices by electric clocks. A motion was made not to receive the report. The proposed ordinance called forth a great display of oratory.

Chairman Graham, Mr. Freeman and Mr. Abrams opposed the ordinance on account of the overhead wire, and Mr. Lawson, Mr. McMullen and Mr. Hoffman zealously advocated its passage. Mr. Henry, representing the company, addressed the committee twice, pointing out the importance of correct time, and the fact that this was a Philadelphia company, and the gentlemen composing it, living in this city, were desirous of testing the method at home before extending operations to other cities. So far from being an experiment or speculation, $5,000 had been already expended, and 500 applications for clocks had been already received, even in that limited territory. Mr. Lawson made a speech, showing how important time had been considered since the days of the Roman empire.

Mr. Freeman thought that it was not a question of time, but of overhead wires.

Mr. Miller pointed out that there would be no poles.

"I understand the importance of time in a broker's office," said Chairman Graham. "When a man's margins are out he wants time."

"No,' said Mr. Lawson, "when the margins are up more margins are wanted, not time."

The ordinance was at last favorably recommended by a vote of 6 to 2.

There is nothing slow about the Bell telephone people where their interests are at stake, and they are likely to make it real "warm" for all trespassers. Bills in equity were a few days ago filed in the U. S. Circuit Court, on behalf of the Bell company, asking to have the following individuals and firms enjoined from using telephones claimed to be infringements upon the complainant company's patents: Joseph H. Bokel, Savery Bradley, Maurice Hayes, C. J. Heppe, Simon Hochheimer, Paul A. Swartz, David H. Bowen & Son, William T. Dowler & Son, J. P. Matheim & Co., Isidore H. Sultzbach, Cuming & Patterson, and Liveright, Greenewald & Co.

As an illuminator, the electric light is becoming very popular in this vicinity.

The "Village Improvement Association" of Wayne (a beautiful and fashionable summer resort on the line of the Pennsylvania railroad, about 15 miles out of town) celebrated the introduction of the electric light into the hamlet by a reception and ball at the Bellevue Hotel, an evening or two since. This is the greatest work so far accomplished by the association. The present plant cost $20,000, and lights most of the cottages in the pretty little village.

The inauguration of the electric light at Wayne will, no doubt, be an incentive for other popular and beautiful villages, such as Ardmore, Bryn Mawr, Haniford, etc., to follow suit and adopt the electric light forthwith. The above-mentioned places are all along the line of the Pennsylvania railroad, within a few minutes' ride of the city.

I hear a rumor that the Pennsylvania railroad company contemplates the more extended introduction of electricity for lighting purposes on their trains. If this is the case, I can't very well see what more the traveler on this road can desire.

Chief-engineer Cantlin, of the fire department, called the attention of the fire commissioners yesterday to the danger, in case of fire, from the electric light wires strung along the streets. He suggested that switches be placed at the street corners, by which the current could be turned off, and thus render accidents impossible. A resolution was adopted requesting the chief of the electrical departments to have the suggestions carried out.

The board of directors of the city trusts recently received a request from city councils to place electric lights along the walls of Girard college, provided it was not inconsistent with the management of the institution.

The college covers a vast area of ground, and should the suggestion be adopted by the Board, it will take a great many lights to fill the bill.

PHILADELPHIA, June 17, 1886.

BOSTON.

More Litigation in the Lowell Syndicate.—Affairs of the Mutual District Messenger Co.—Testing a Police Patrol System.—Annual Meeting of the Franklin Telegraph Co.—Underground Wires for the Edison Company.—Proposed General Underground System of the Woodward Company.

SOME months ago I made the remark, in alluding to the notorious Lowell telephone syndicate, that if the inside workings of that partnership could be disclosed, it would make mighty interesting reading. I gave you a sample last month, the result of a falling out of the members of the syndicate. There are proverbs which could be aptly cited in this case, in view of the disgorging of some $35,000, recently by these parties. The hearing in the Erie telephone case was resumed in Lowell on June 2d. This is a suit of Wm. H. Bent, one of the syndicate, against the Erie Telephone Co., to recover salary due for services as attorney.

The annual report of the general manager of the Mutual District Messenger Co. says: During the year ending April 30, 1886, we reconstructed a large portion of our old lines, constructed 14 miles of new line, and increased the number of call boxes in circuit 306, making a grand total of 184 miles of wire and 3,423 call boxes. In addition to this we have constructed 42 short private lines connecting the important hotels and broker offices with our main office by annunciators, which enables us to give the very best kind of service, and control the messenger service at these places. During the year we delivered 1,269,629 and collected 599,467 telegrams, showing a falling off of 114,331 messages delivered, but showing an increase in the collection of the same. The amount of tolls accruing to the Western Union and Mutual Union Telegraph companies from these messages collected was $145,981.49. Our messengers answered 515,603 calls during the year. The earnings for the year ending March 31, 1886, were: From telegraph service, $68,210.70; from district service (including box rentals and laundry commission), $25,436.39; from interest on deposits, $14.16; making a total of $93,661.25. The operating expenses were $72,203.48, while the general expenses, maintenance and taxes, were $2,504.22, making a total of $76,-089.70; net earnings for the year ending March 31, 1886, $17,571.55.

There was given on the 2d inst. in the afternoon, at police division 6, South Boston, a thorough exhibition of John C. Wilson's police patrol system which has been placed in the section of the city above named for a prolonged trial previous to its adoption or rejection by the city council. The test, which was the first that had been made, was witnessed by police commissioner Whiting, Lee and Osborne, together with the ex-chairman of the old board, Dr. Thomas L. Jenks, and superintendent of police Small, deputy superintendent Burrill and captain Eldridge of division 6. The commissioners and Dr. Jenks drove over to the station house at about 1.30 o'clock, and examined the telephone board, and time and patent registers as they stand ready for immediate use in a small room in the station house. The working of the system was thoroughly explained by Mr. Wilson, and then the stable, which is connected with the station by a passageway and speaking tube, and which faces on Athens street, was visited, and the horse and new police wagon were examined. The wagon will be used for the purpose of carrying police, prisoners, and also in case of emergency, it can be converted into a comfortable ambulance.

At about two o'clock the commissioners, with Dr. Jenks, drove from the station house to the patrol box on Swett street, where they rang for the wagon; but on account of some accident, the signal was not received at the station, and so the box on the Dorchester street bridge was visited. At this place a call was sent for the wagon. The call was received by the operator at the station, and he in turn communicated with the driver of the police wagon by means of the speaking tube, and in just four minutes and a half from the time the call was given, the wagon, containing captain Eldridge, a policeman, and a newspaper reporter stopped in front of the box. The commissioners then drove to another box and sent a call to the station, which was repeated to captain Eldridge, who was at the box on Dorchester street. The wagon again went flying through the thoroughfares to the corner of E street and Broadway, making the distance in less than three minutes from the time the commissioners made the call. As the commissioners made their own selection of boxes without the knowledge of the driver, the test was considered as very satisfactory. The keys to the police signal boxes were distributed to the patrolmen of division 6 on the 4th inst. The first alarm was turned in by officer Joseph Knowlton from box 54, corner of First and B streets, and the wagon arrived in about two minutes. The services of the men, however, were not needed. The police are much pleased with the system. Heretofore, in South Boston, where a rough element resides, it has been as much as a patrolman's life was worth to attempt an arrest in a crowd. On the 8th inst. the police commissioners, with a view to testing another police-signal system, detailed one of their number, Mr. Lee, to visit Charlestown for the purpose of selecting a location for a patrol wagon. Mr. Lee visited Charlestown yesterday, but was unable to find a suitable location, and as the commissioners are

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debarred from purchasing property, the citizens of Charlestown will not at present enjoy the benefits of the signal system.

At the annual meeting of the Franklin Telegraph Co., the following named officers were elected: Directors, Charles A. Tinker, Thomas T. Eckert, Jay Gould, A. R. Brewer, Frederick L. Ames, Thomas Roche, Norvin Green, John Van Horne, J. F. Greenough; secretary and treasurer, R. H. Rochester; clerk Thomas Roche.

The Edison Electric Illuminating Co. was authorized to lay wires underground on Tremont, Carver and Pleasant streets, Shawmut avenue, Indiana place, Washington, Kneeland, Albany, Kingston, Summer, Arch, Milk, Congress, State and Court streets to Tremont streets.

Before the board of aldermen on the 9th inst., a petition was received from the Woodward Underground Telegraph and Telephone Co. for permission to dig open the streets of the city to lay all telegraph, telephone and electric light wires therein. The plan proposes the construction of an underground way so capacious as not only to take in all the wires that now are carried overhead, but all that will be required during the next twenty years. The petitioners in consideration of the privilege, if it shall be granted them, will agree to put in all fire alarm and municipal wires at cost, and to pay one per cent. of the gross receipts from all sources into the city treasury. The petition was referred to the committee on underground wires on the part of the aldermen.

BOSTON, June 16, 1886.

CHICAGO.

Indiana Telephone Affairs Quieting Down.—Probable Adoption of a Toll System.—Effect of the New Orleans Decision.—Taking Down Poles in Chicago.—A Decided Improvement in the Appearance of the Streets.

MATTERS down in Indiana have somewhat settled, either because the telephone case has ceased to be a nine days' sensation, or the papers have talked themselves out. The people who are most interested in having telephone service, and especially those who had experience with the Indianapolis system, are as much in earnest as ever, and but for the ill-advised law which prevents, would undoubtedly rejoice to have the situation restored to its status before the present unpleasantness. By the time this correspondence sees the light, the trouble may perhaps be so far quieted as to be considered virtually ended. Unless all signs fail, the system which President Phillips has submitted to several of the towns in the state will be quite generally accepted, and the law satisfied, while the public are well served. I refer to the toll system, which differs somewhat from that of any other locality. Should this system prevail in Indiana, it will bridge over the gap until the learned law-makers, having failed to accomplish any good by their action, will be ready to undo the work.

And the many other, better, easier, cheaper systems which have been clamoring for the crumbs that fell, or that they hoped would fall, now that the Bell people are regaining lost ground, will pack and tramp from what a few weeks ago each looked upon as a future paradise for him and his system.

The New Orleans decision was a sort of Mrs. O'Leary's cow, that kicked over the lamp and consumed the hopes of all the outside companies, from the Pan-Electric down to the last individual variety of the last genus of the species.

The recent exposition of the disgraceful connection between public officials and the telephone scandal have shown up an existing condition of infamy which it would be difficult to believe, were not the proof pat and perfect; and a member of Congress speaking of the conspiracy which was entered into to manipulate Bell stock in accordance with the decision of Secretary Lamar, which decision was known to the conspirators some days before it was given to the public, stated that while the committee knew of the conspiracy, and were aware of the fact that the leaky vessel was a woman friend of a Washington gentleman, the resolution did not in reality cover the case, and it was not enquired into, because of a great social scandal which would follow the investigation.

It must have become patent to all unbiassed minds, by this time, that in all this matter there has been no idea of justice, or right, or honor, or fair dealing, in compelling the Bell company to defend against such monstrous charges as have been made. The object was solely and only to hamper the company, by accusation. To claim that this accusation was equivalent to conviction. To prevent the courts interfering by injunction—because of the accusation—and thus permit wholesale piracy on the Bell company and the public generally, by the sale of stock and the opening of exchanges at every opportunity. The New Orleans fight was based on this argument and went down.

Indiana has been considered an open field by the anti-Bell people, and thither they flocked, each with a system of his own, which was entirely new, entirely different from the Bell, each based on the original inventions of some one previous to Bell. This dissimilarity is testified to by an expert in Indianapolis, who said that at least one of the rival machines did not look like Bell's.

Now that the New Orleans matter has developed "circumstances over which we have no control," as an officer in a pseudo telephone company said the other day, it is not at all unlikely that the day of opposition telephones has nearly reached the quitting time of an eight hour service.

The streets of Chicago are beginning to change in appearance —for the better. The poles and lines are disappearing quite rapidly.

The city's wires have been gradually taken in and sent below, until the south side lines, comprising some thirty-five miles of city wires, have disappeared from the lake to the south branch, and from the river to Van Buren street, and there was not a street in that entire district that had not one or more fire alarm, police or other city wires.

The Western Union people have removed the poles on Lasalle, from Washington to Jackson, on the west side of the street. These were 55 feet high, and were so thickly strung with line wires that they fairly cast a shadow upon the walk.

A heavy line of poles on the east of State street has been removed from 12th to Harrison. North of the office at Lasalle and Washington, the company will lay a conduit pipe, and reach the tunnel, when the poles along this route will disappear. In short, the Western Union will very soon clean up through all streets in the south division north of 12th street.

The largest poles in the city were those of the Mutual Union company, from 12th street, running to the corner of Lasalle and Washington. These ranged grom 55 to 90 feet, and are all down.

The Baltimore and Ohio are preparing to remove everything north of Harrison street in a few days

The telephone company has arranged to put its wires underground on the following routes at once: Starting at Calhoun place on Lasalle, north to Washington, east to Dearborn, south to Jackson, and east to the Alley, south on the Alley to 20th street; east to the Alley near Michigan avenue, and south to 22d street. This will pretty much clean up the telephone company's wires on the south side. On the west side commencing at Green street on Madison, the pole lines will be removed to Ashland avenue; thence north to the Alley, which will greatly relieve that portion of the city.

The Mutual Union has also made arrangements for conduits on Lasalle from Washington to Lake, and along this latter street from Fifth avenue to Michigan avenue, with lateral crossings north of Randolph, west of Dearborn, and east of Michigan avenue.

To an old resident the aspect of the business portion of the city is, to say the least, peculiar. The streets look wider, the view is less interrupted, and it really does appear lighter, and, while it is claimed by some that the place is stripped of some of its city characteristics, it is hardly to be believed that the day is approaching when a bell-ringer will daily call the denizens of the place to come and weed the thoroughfares.

CHICAGO, June 14, 1886.

SAN FRANCISCO.

Capital Not Anxious to Engage in Competitive Schemes.—The Brush Company Holds the Fort.—A Practical Underground Commission.—Where is the Electric Railway?—Reign of Peace Between the District Companies.—Some of the Grievances in the Western Union Office.

IT is difficult for a correspondent to fabricate things that ought to, but do not, exist, in a community like this; but, with all our cosmopolitan forwardness and oriental grandeur we are in many respects lamentably behind your eastern cities. Our capitalists want a monopoly and a fortune, or nothing. They will not lay out a cent for public good or human benefit if it does not promise immediate and enormous profits.

The district system, the telephone, the electric light and all such were "gobbled" up by a few. It is true rival district companies were started as well as competitive electric light companies. The California Electric Light Company (Brush system) so manipulates the board of supervisors that a rival company can not get a smell at a franchise to lay wires, or string them, and here is a sample of what our board of supervisors will do, which for utter ignorance or downright effrontery, stands at the head of any of Tweed's modes of manipulation. They appointed a committee, composed of George S. Ladd, John I. Sabin and George Rowe to report to them the advisability and practicability of laying wires underground. Dean Swift said there was no use going to law against the devil with the court in hell—he would prefer a change of venue; neither is there any chance to beat a corporation, with a foothold, and money, in San Francisco. Therefore the Brush company strings wires in every direction (and very slovenly is it done, too) upon short poles. When it is too late the city will rue it, but our supervisors are like Mr. Vanderbilt, and exclaim, "the public be d——d." Hence the electric light company as well as the telephone has a monopoly, and the shareholders are becoming rapidly rich. Now, while such little things

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as the Stockwell system of motors for sewing machines promised a decent percentage on the outlay a company could not be formed to set it in operation, because there was not a fortune in sight. Equally so with James Gamble's efforts to get sufficient capital subscribed to build from San Francisco to Albuquerque or Salt Lake, a telegraph line to meet the Mutual Union or Baltimore and Ohio, because they did not see 50 per cent. of expended capital rolling back to them in two years. They care nothing for rivalry or the healthy influence it would have on commerce; hence if providence and eastern capital and pluck will not build another transcontinental telegraph line, the Western Union will bask in the sun of complete control.

Professor Keith's electric railroad must be dead, for we hear nothing of it; but occasionally in the reading room of the Palace Hotel the professor can be seen with a great deal of "speculation in his eye."

The district war is over. Phillips and Gill met over a quiet schooner of beer, then president Jaynes met president Ackerman in the Union club, and what the superintendents began the presidents ratified, and they mutually agreed to run as rivals, but not to reduce rates, or offer a bonus for privileges. Gill and Phillips straightway bought new suits of clothes at a fashionable tailoring establishment, thinking they had expended enough treating the landlords of boarding houses and high toned saloons.

Superintendent Jaynes of the Western Union Telegraph Company created quite a stir amongst telegraphists a few weeks since by peremptorily discharging two of his oldest men for the alleged cause of being leaders in a secret organization and creating dissatisfaction and dissension. There is no doubt but that Mr. Jaynes's mind had been prejudiced by designing enemies of these men, or zealously demonstrative underlings who, lacking ability and manhood, must manifest their loyalty in some way. That these men were capable, honest and faithful in the discharge of the duties imposed upon them no one denies, nor does the management question it, hence I come to the conclusion that some pernicious influence was at work. The old men in the office complain of many grievances, and men who have been loyal to the company, as well as good men who were strikers. Not the least is, that of taking men who were working *extra* at $75 per month and placing them over the heads of tried men at a much larger salary. They could not claim superior knowledge, for they were totally ignorant of the duties to which they were assigned. Again, strange men come into the office inferior operators to those already in it, and because they are friendly to the chiefs their salaries are increased to a greater amount than that paid to older employés, and eminently better operators. These are grievances, and men ought to be heard. A man named Howe came here from New Orleans. He was not in the office a fortnight before he went to the chief operator and told him the men were "organizing." The chief operator repeated this *verbatim* to the operators, and hence Howe's existence in the office afterwards was a few degrees warmer than purgatory. A climax arrived, and it is asserted that Howe went to Mr. Jaynes and added fuel to an already enkindled fire, by corroborating almost all his suspicions. Howe is undoubtedly a man to be avoided, yet he is not alone to blame. Mr. Jaynes has too much to attend to to be able to devote much attention to the details of the operating room, and must necessarily depend on those in charge for information, and the operators lack the courage to go direct to Mr. Jaynes with their grievances, because they fear the wrath of the underlings. Mr. Jaynes has always been recognized as the operators' friend, and in fifteen years experience I have not known of a man who has gone *direct* to him that did not come back satisfied. This would be the better course for operators to pursue, instead of denouncing a gentleman through their organ who has always been just.

SAN FRANCISCO, June 14, 1886.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICIAN AND ELECTRICAL ENGINEER, 115 *Nassau Street, New York city.*

PRACTICAL DYNAMO BUILDING.—CORRECTION.

[54.]—In the article on "Practical Dynamo Building," in your June issue, I notice an error which seems quite obvious. On page 211 at the foot of last column, occurs this statement :—

"The armature is divided when running, into two portions by the brushes upon the commutator, hence, half the total length should be taken in the calculation."

Now, it is easily shown that only *one-fourth* the total length should be taken into calculation, as resistance on ordinary closed coil armatures, because the current flows through one-half the total length of wire wound upon the armature, consequently one-half the resistance of whole length.

Now, it not only is one-half the total length, but *the two halves* are *always in parallel.* This reduces the resistance of the armature another half; consequently, the resistances of all closed coil armatures (as ordinarily used) are one-fourth the resistance of the total length of wire on the armature. This I have demonstrated several times by actual measurement.

LYNN, Mass., June 6, 1886. OSBORN P. LOOMIS.

[55]—In the ELECTRICIAN AND ELECTRICAL ENGINEER for June, pages 211–213, article on "Practical Dynamo Building for Amateurs," the writer says :

"The armature is divided, when running, into two portions by the brushes upon the commutator, hence half only of the total length should be taken in the calculation. A reference to column *a* in the following table will provide a multiplier for ascertaining the resistance of the length of conductor. The resistance per yard of No. 16 B.W.G. is here shown to be .0073 ohm; therefore, half the length of the conductor, $\frac{333}{2} = 166.^6$ yards, and $166.^6 \times .0073 = 1.2$ ohm."

As I understand it, the armature is of the Gramme type, and if so, of course the two halves are in multiple arc, consequently the resistance of the armature, when running, should be only ¼ the resistance of the total length of wire; $\frac{333}{2} = 166.^6$ yards of wire in each half, and $166.^6 + 166.^6$ in multiple arc would have but half the resistance of one of the branches, or $\frac{166.6}{2} = 83.^3$ yards $\times .0073 = .6$ ohm instead of 1.2 ohm, as written. Which is right? AMATEUR.

[Both of our correspondents are correct in their supposition that the resistance of the armature would be .6 instead of 1.2 ohms.—EDITOR.]

THE "BUG" IN THE QUADRUPLEX.

[56.]—To the great majority of your readers the combination of apparatus known as the Western Union quadruplex is so familiar as to require no explanation. It is also only too apparent to those having charge of the instruments, that in its operation there exists a defect which for want of a better term has been called "the bug."

A great deal of inventive ingenuity has been expended in endeavors to remove this defect, but so far without complete success, the most operative devices being those involving a slight mutilation of the arriving signals.

It has been almost universally supposed that the "bug' is caused by the reversal of the current at the distant station. That this is not the case is proved by the fact that the employment of apparatus tending to bridge over the period of no current, fails to remove the defect, while it rarely appears when the home keys are in a state of rest.

In the organization of the apparatus there are two differentially wound relays, the terminals of which are connected, one to the line, while the other goes to the equating or rheostat circuit. The line having a static capacity requires a similar capacity in the equating circuit, which is obtained by the Stearns condenser attachment.

For the outgoing currents these two static effects exactly neutralize each other—not so, however, for the incoming. To this fact may be ascribed the disturbing influences of the "bug."

The incoming current on arriving at the point of battery contact divides and part flows through the equating circuit to the earth, the amount depending upon the resistance of the home battery.

When the home reversing key is actuated, there is an instant when all four contact points come together, and the battery resistance is eliminated. The effect of this removal of resistance is to tend to bring the equating condenser to zero and diminish the static charge on the line. Upon the completion of the stroke of the home key the original condition of things is restored, and the equating condenser receives a charge from the distant battery, which passing through both coils of the relay in the proper direction, causes a momentary flutter in its magnetism not caused by the distant, but by the home key.

This then is clearly the cause of the disturbance—whatever tends to diminish the resistance of the line battery gives greater working margin by diminishing the amount of the charge taken by the equating condenser from the distant battery.

It seems that while the condenser affords a ready balance for outgoing currents, it adds an element of uncertainty to those incoming in cases where the home battery has any considerable resistance.

The foregoing explanation affords a reason for the difficulty experienced in working what are known as straight current quads,

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also many forms of sextuplex. In both cases the relay and battery resistance being largely increased have a tendency to enlarge the error pointed out. It has been urged that the contacts of the pole changer points are so nearly instantaneous that their effect may be neglected, and tests made with the pony duplex when one relay is included in the battery circuit, cited in proof of the theory. This proof, however, will not answer when the conditions of the case are analyzed. In the pony duplex we have the wire on the relay in one coil circuit, which, it is well known, exercises a retarding effect upon instantaneous impulses of electricity. In the case of the quadruplex, the wires being wound differentially by self-induction eliminate the retarding effect, and a marked discharge of the condenser and line ensues.

Some years since, when in Buffalo, I was informed that a very lively dispute was in progress between the officials in that city and New York, as to the size of battery cells to be employed. New York arguing that the signals were the same, whichever sized cell, No. 1 or No. 2, was employed; while Buffalo insisted that the apparatus worked better with No. 1 cell, which has a decidedly lower resistance. Of course both were right. New York would get Buffalo's signals equally well with either sized cell. But the increased resistance of the No. 2 cells used at Buffalo would mutilate the arriving signals, owing to the increased resistance short circuited by the Buffalo pole changer.

It seems to me that very great improvement can be made in the operation of all forms of multiplex apparatus by the use of batteries of very low internal resistance. I have, by recent experiments, determined that an electromotive force of 300 volts, with an internal resistance of 150 ohms, can be reversed with suitable apparatus without sparking, and with perfect safety. Such a source of energy applied to the present multiplex apparatus would undoubtedly lead to more better transmission on a single wire, and a consequent increase of revenue to the various telegraph companies. STEPHEN D. FIELD.

YONKERS, N. Y., June 11, 1886.

LITERATURE.

REVIEWS.

Abridgements of United States Patents on Underground Lines, to January 1, 1886. 344 pp., 16mo. Published by the author, JAMES W. SEE, Hamilton, O. Price $10.

THIS publication fairly recognizes the importance of the underground question, and is the first attempt toward presenting in a compact form the numerous American patents which have been granted for various devices in this line of invention. The work appears to be very complete, and the abridgements of the specifications, together with the claims which are printed in full, form a trustworthy guide to the inventor who seeks to ascertain what has already been done The record begins with the patent of S. F. Van Choate, granted November 9, 1869, which is followed by that of E. H. Austin, April 22, 1878. The whole number of patents is 323, including re-issues.

A more extensive work, by the same author, is a volume of 1,800 imperial 8vo pages, containing over 1,600 figures, with a digest of 7,000 references. It is, in fact, a complete reprint of the official copies of the patents as issued by the patent office. In connection with these publications, a brief sketch of the state of the art prior to 1869 would be of interest. The material for this is not readily accessible, as underground work at that date was limited to Europe, and most of it did not prove to be of a very reliable character. As a matter of fact, the compilation of Mr. See is the only fairly comprehensive collection of underground electrical patents before the public.

RECENT PUBLICATIONS.

Cadiat, E. and Dubost L. Traité Pratique d'Electricite Industrielle. Paris: *Baudry & Co.* 584 p., illustr. 8°. Price 15 francs.

Fontaine, Hippolyte. Electrolysis, a practical treatise on nickeling, coppering, gilding, silvering, the refining of metals and treatment of ores by means of electricity. Translated from the French by J. A. Berly. London and New York: *E. and F. Spon.* 256 p., 34 illustr. 8°. Price $3.50.

Hedges, Killingworth. Precautions on Introducing the Electric Light, with notes on the prevention of fire risks. London and New York: *E. and F. N. Spon*, 1886. 118 p., illustr. 16°. Price $1.

Report of the Electrical Conference at Philadelphia in September, 1884. *Government Printing Office, Washington, D.C.*, 1886. 186 p., illustr. 8°.

See, James W. United States Patents on Underground Lines to January 1, 1886. Hamilton, O.: *J. W. See.* 1,800 p., illustr. 8°. Price $50.

See, James W. Abridgements of United States Patents on Underground Lines to January 1, 1886. Hamilton, O.: *J. W. See.* 344 p. Price $10.

Walker, David R. Annual Report of the Electrical Department of the City of Philadelphia for 1885. 42 p. 8°.

Watt, A. Electro Deposition. A practical treatise on the electrolysis of gold, silver, copper, nickel, and other metals and alloys, and several chapters on electro-metallurgy. London: *Crosby, Lockwood & Co.* 568 p., illustr. New York: *D. Van Nostrand.*

ELECTRICAL NEWS AND NOTES.

THE NEW ORLEANS TELEPHONE DECISION.

AMERICAN BELL TELEPHONE CO. ET AL. v. NATIONAL IMPROVED TELEPHONE CO. ET AL.

Circuit Court of the United States—Eastern District of Louisiana.

OPINION OF THE COURT.

This cause is before us on an application for a preliminary injunction, upon bill, answers, numerous affidavits, depositions and exhibits. We heard the application discussed by the solicitors on both sides, with many adjuncts of experiment and illustration, for the period of twenty-one days, and we have striven to give to the question the study and consideration to which it is entitled, from the fact that so many of our fellow-citizens throughout the entire country are interested in its decision.

A very long discussion, in which solicitors of ability and learning participated—such as has been the one conducted before us—has one great advantage: it tends to separate, by a clear line of demarcation, that which is sound in law and sustained in fact, from that which, however plausible and forcibly urged, analysis and proof compel the abandonment of.

The complainants have urged that since the patents involved here have been the subject of judicial investigation, ending in decisions in the circuit courts of the United States maintaining their validity, that so far as the issues presented in those causes have been identical with those involved in this cause, for the purposes of granting a preliminary injunction to run *pendente lite*, those prior decisions elsewhere obtained are sufficient. We assent to this doctrine.

The proofs submitted to us include decrees affirming these patents by Mr. Justice Gray, Mr. Justice Matthews, Judge Lowell, Judge Blatchford, Judge Wallace, Judge Nixon, Judge Mc Kennan, Judge Butler, Judge Acheson; with opinions at more or less length by Mr. Justice Gray, Judge Lowell and Judge Wallace. It has been urged by the respondents, that in all these causes save one, there was either an absence of one or more of the defenses here urged, or collusion between the parties and consequent imposition upon the courts; so that the decrees and decisions submitted and referred to above, should not, of themselves be the basis of the decision and decree here. In the Molecular case, decided by Judge Wallace last June, there has been no charge of collusion and consequent imposition. We think that these causes abundantly show that the substantial defenses here submitted have been urged in several of those cases (though perhaps they have not been urged with the vigor and persistence that have characterized the defense here), and that the settled practice in the circuit courts of the United States would authorize the granting of the injunction *pendente lite*, upon the authority of the decrees in those cases.

We do not understand that the weight given by one circuit court to the adjudications of another, rests entirely upon the basis of comity; but as well upon that of recognized rights and of convenience, and that it is largely to prevent the necessity of more than one court going through with the investigation of the same facts, that the inference derived by the first court is for the purpose of determining whether or not an injunction shall go, till the final decree adopted by the other circuit courts. In addition to the weight to be given to the adjudications in favor of the Bell company in other circuits, on the basis of convenience, comity and recognized rights, it is urged that the National Improved Telephone Co., the principal defendant here, is estopped by the final decree rendered by Judge McKennan in the Pittsburg case, because it was privy to that suit, and had a day in court there.

The evidence shows that the National Improved Telephone Co., claiming to own certain patents pertaining to telephony, was the licensor of the Pittsburg company, and contracted, for a consideration received, that in case of any litigation involving the validity of said letters patent, or any of them, wherein the Pittsburg company should be a defendant, the said National Improved Telephone Co. should have prompt notice thereof, and should assume control of said litigation, and at its option be made a party thereto at its own expense; that the Pittsburg suit did involve the validity of said letters patent; that the National Improved Telephone Co. was promptly notified thereof, and did assume control of the litigation; preparing an elaborate defense and appearing therein by counsel, who were heard by the court, and that becoming dissatisfied by the refusal of the court to go behind the decrees of other circuits in the matter of a preliminary injunction, the National Improved Telephone Co. "ordered the immediate withdrawal from the court of all the evidence, instruments, and documents of every character connected with the defense," and "immediately dismissed the counsel in said case."

In *Robbins* v. *Chicago*, 4 Wallace, 657, it is said:—

"Conclusive effect of judgments respecting the same cause of action and between the same parties rests upon the just and expedient axiom, that it is for the interest of the community that a limit should be opposed to the continuance

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of litigation, and that the same cause of action should not be brought twice to a final determination.

Parties in that connection include all who are directly interested in the subject-matter, and who had a right to make defense, control the proceedings, examine and cross-examine witnesses, and appeal from the judgment.

Persons not having those rights substantially are regarded as strangers to the cause, but all who are directly interested in the suit and have knowledge of its pendency, and who refuse or neglect to appear and avail themselves of those rights, are equally concluded by the proceedings."

See also *Chicago* v. *Robbins*; 2 Black 418.

To the same effect are *Cromwell* v. *County of Sac*, 94 U. S. 351 *Chamberlain* v. *Preble*, 11 Allen, 370; *Tredway* v. *The Sioux City & Pacific R. Co.*, 39 Iowa, 663.

The rule is applied in patent cases. *Robertson* v. *Hill*, 6 Fisher, 465; *Miller* v. *The Liggett & Myers Tobacco Co.*, 7 Fed. Rep., 91.

No authorities are cited to the contrary, but counsel have argued that the National Improved Telephone Co. had a right to withdraw from the litigation, and that thereupon, in some unaccountable way, the company was released from all responsibility, and that complainant had no right to proceed to a decree.

We cannot avoid the conclusion that so far as the National Improved Telephone Co. is concerned in this suit, that it is bound and concluded by the final decree rendered at Pittsburg, and that that decree alone warrants the injunction *pendente lite* in this case, as against said telephone company and its privies.

But since we have had the cause so exhaustively presented, and we have so fully considered it, we have determined not to rest our conclusions upon the decrees in the other circuits, sufficient as we deem those to be, but to examine the questions *de novo*. It is urged by the defense that there should be given a weight to the fact that the executive department of the government has directed the institution of a suit to annul this patent, that should lead us to refuse or defer any affirmation of the patentee's rights till the conclusion of that suit. To this we cannot assent. The executive department has not in this case attempted to adjudicate rights, nor could it in any case do more than start the judicial inquiry, and present the cause to the courts. The filing of an information cannot create a presumption of guilt. No more can the institution of a suit to annul, create a presumption of nullity. If any effect is to be given to the pendency of this suit to annul, so as to suspend any rights of the patentee, it could only result from restraining or other orders issued in that suit, where the court, having the parties and the evidence upon which the nullity is sought to be established, before it, has also the authority, if to annul, then to suspend the force of the patent.

There is a class of cases where the decision of the executive is conclusive upon the courts. This class includes only those which present political questions, such as which is the lawful government in a state or in a foreign country—questions connected with functions of sovereignty, where promptness and unity of action in all the departments of government are essential. All questions properly judicial are by the very constitution embraced within the judicial power, and submitted exclusively to the courts. It is necessary to consider two grounds of the invalidity of the letters patent of Alexander Graham Bell, No. 174,465, issued March 7, 1876, on application filed February 14, 1876.

First, it is urged that after the filing of Bell's application—his specifications and claim were changed in consequence of information, derived through the examiner of the patent office, from the caveat of Elisha Gray, filed on the same day with Bell's application. We have reached the conclusion that the invention is set forth in the claim and specifications as originally filed, and that, therefore, any inquiry into this question would lead to nothing which could affect the validity of the patent. It is overwhelmingly established that Bell made the affidavit to his claim and specifications as originally filed, on the twentieth day of January; and that Gray's description of his invention embodied in his caveat, was not written out till three or four days prior to February 14, when it was filed.

The fifth claim of Bell originally filed, is as follows :—

"5. The method of, and apparatus for, transmitting vocal or other sounds telegraphically, as herein described, by causing electrical undulations similar in form to the vibrations of the air accompanying the said vocal or other sounds, substantially as set forth."

In the specifications originally filed by Bell there is the following figure and description and illustration of the apparatus and process.

"Another mode is shown in figure 7, whereby motion can be imparted to the armature by the human voice or by means of a musical instrument. The armature *c*, figure 7, is fastened loosely by one extremity to the uncovered leg *d* of the electro-magnet *b*, and its other extremity is attached to the centre of a stretched membrane, *a*. A cone, A, is used to converge sound-vibrations upon the membrane. When a sound is uttered in the cone the membrane *a* is set in vibration, the armature *c* is forced to partake of the motion, and thus electrical undulations are created upon the circuit E *b c f g*. These undulations are similar in form to the air vibrations caused by the sound—that is, they are represented graphically by similar curves. The undulatory current passing through the electro-magnet *f* influences its armature *h* to copy the motion of the armature *c*. A similar sound to that uttered into A is then heard to proceed from L."

To simplify : In the fifth claim and the part of the specification quoted above, the applicant declares that his invention consists in this: In the discovery that vocal or other sounds, by being uttered or otherwise communicated through a receiver, and by reason of their force being made to impinge upon an armature, impart to it the vibrations of the air; that these motions of the armature cause corresponding undulations in the electrical current, so that, at the end of the circuit, similar vibrations are given to another armature, through it to the surrounding air, and through the air to the human ear. Thus voice is communicated to the electrical current, and reproduced at the end of the wire in the air, and all this by reason of the discovered fact that vibrations in the air caused by sound, are so similar to the undulations in the electrical current, that vocal sound, of whatever character itself, may be passed from air to the electrical current, and delivered again through the air by means of a receiving and a delivering, or emitting armature. The great discovered fact was that the vibrations in the air are similar in form to the following and imparted electrical undulations, and that the undulations are similar to the ultimate vibrations. It follows that as are the vibrations so are the undulations, whether gradual or sudden, of whatever pitch or loudness, whether constant or varying in pitch or loudness, whether caused by a single or by successive sounds. We think this a sufficient description of the process and apparatus and of the whole discovery patented, and that it neither required nor did it receive any substantial changes by the amendments subsequently made, no matter from what source suggested or derived.

Another objection urged by the defense was that the apparatus described in the specifications, and illustrated by figure 7, is not capable of transmitting articulate speech. There are affidavits to this effect, but the affidavits in favor of the capability are very strong and satisfactory, and the court itself, through its own senses, was convinced that the transmission of speech had been completely attained by means of the Bell apparatus, as exhibited by figure No. 7 The fact that Bell's invention certainly dates

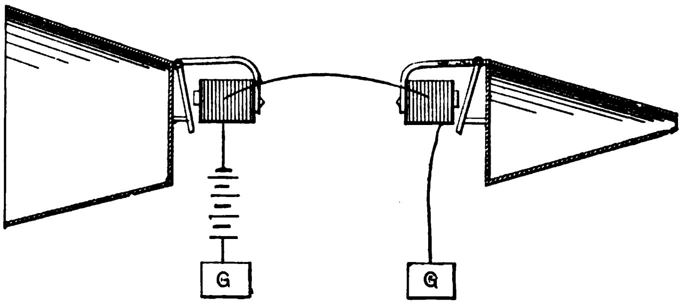

FIGURE 7.

from January 20, 1876, and that it covers a speaking telephone, transmitting articulate speech by means of an undulatory, oscillatory or vibratory current of electricity, renders it unnecessary to pass upon the evidence relating to the tergiversations and claims of Gray; the alleged frauds of Bell in advancing his application for a patent; the illegal conduct and conflicting estatements of examiner Wilber; and many alleged vices and irrgularities, the evidence of which forms the bulk of the record, and apparently the main defense in the case. At the same time, it is proper to say that in all the evidence, we have found nothing that shows that Bell has done or caused to be done anything inconsistent with his right to be called an honest man—with clean hands.

If he availed himself of information derived from Wilber as to the contents of Gray's caveat, filed on the same day as his (Bell's) application (which, however, does not appear), he had a right to do so to enable him to restrict and limit and clearly define his application; as the information shown to have been furnished, was furnished under the authority of rule 33 of the patent office for such purpose. We will next consider the second ground of defense, which is that the invention of Bell lacked novelty, because it had been anticipated by Philipp Reis. That Reis made great strides toward the discovery of the great fact or law, subsequently announced in the fifth claim of Bell, does not admit of doubt. That he failed to reach it is equally beyond question. Reis discovered that by means of the electrical current, sound could be received, transmitted and delivered. But it was the pitch of tones that was transmitted, and exclusively by means of an intermittent make-and-break current—a current incapable of conveying the form of sounds, protracted or varying sounds, and therefore incapacitated to convey articulate speech. His apparatus appears to have been devised in the attempt to transmit speech by electricity; but the attempt was an acknowledged failure. His apparatus under the influence of the voice or other sounds, simply broke the circuit at each principal vibration with a frequency corresponding to the pitch of the sounds.

Prof. Trowbridge says :—

"It is impossible to transmit speech electrically by means of that operation; for the reproduction of articulation requires the

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reproduction not merely of the *number* of sonorous vibrations, but what is technically known as their *form* or character. The electrical changes on the line wire which are to convey this characteristic from the transmitter to the receiver cannot do that unless they take note of that characteristic and bear its impress. This is as certain as any elementary proposition of geometry."

Reis apparently had no idea of operating through a continuous, uninterrupted current, which should be undulatory, *i. e.*, should be plastic, impressible and should be the medium of receiving freely and continuously, and reproducing exactly the vibrations in the air accompanying sound, by the corresponding disturbances in the electrical current, without any intermission of the flowing of the current. In the Jahresbericht, or the annual report of the Physical Society of Frankfort for the year 1860–61, is an account given by Reis himself of his invention and apparatus. It was presented to the court as translated in the biographical sketch of Philipp Reis by Silvanus P. Thompson, published in London in 1883 Upon a suggestion that the translation might be imperfect, we ordered that the memoir should be obtained from the congressional library, and should be translated into English by J. Hanno Deiler, Professor of German in the Tulane University. We have carefully compared Mr. Reis's description of his invention and apparatus as given in the two translations. While differing in the words used in the two renderings, they agree in making Reis state that he uses an "intermittent current," and that "each sound wave effects an opening and closing of the current." This is made even more palpable by his illustration of his apparatus or instrument. This is entirely inconsistent with any idea of a continuing current which should undulate, *i. e.*, be increased or diminished merely, by an apparatus so constructed as to be susceptible of being set in motion by the vibrations of the air produced by sound, and should freely receive, convey and deliver single or successive sounds, by reason of being so constructed as to be capable of being started and continued in motion just so long as the vibrations of the air lasted. He did not apply to his instrument the law—indeed, he seems not to have designed his instrument with any reference to the law—that the vibrations in one medium had an exact correspondence to the undulations in the other, not only for an instant, but for any period of time.

The merit, and, as we think, the originality of the Bell invention consisted in the discovery of this law, and in the construction of his apparatus so that when the sound caused aerial movements or vibrations, they might, without any intermission of the current, be freely transferred or translated into electrical undulations, which again, at the end of the circuit, would freely reproduce the aerial vibrations, and thus convey, single or combined, transmitted sounds to the ear, and continue to convey them without interruption, as originally uttered, whether single, combined or successive. Reis's result was that sound could be sent through the electric current like a missile through the air; Bell's result was that the electric current was a continuing connection between voice and ear, like the air itself. A great fact in proof of the correctness of this deduction is that the instruments invented by Reis and his methods were described in many scientific papers and works, and were well known in the scientific world, and the instruments were manufactured and on sale in Paris, Vienna and Frankfort, and had been exhibited before the British Association, and a pair were deposited in the Smithsonian Institution; and yet before 1876 there was no speaking telephone in use, nor any pretence of any.

The various reproductions of Reis and his methods, all were based upon the same defective electrical means,—an intermittent circuit-breaking current,—and all were practical failures for the transmission of speech, until Bell's method was discovered. From the evidence submitted in this case it seems clear that now, in the present state of the art, neither the Reis instruments nor any reproduction of them can be made to transmit articulate speech, except by changes of some form in the instruments themselves, or by the employment of Bell's method. We, therefore, conclude that neither Reis nor his successors anticipated the invention of Bell as set forth in the fifth claim of his application and patent, and as illustrated by figure 7, described in his accompanying specification.

The Meucci defense that is brought forward in defendants' record on this motion, taking up one hundred and twenty printed pages, was abandoned by counsel on the hearing, and no effort made to sustain it. There remains, therefore, but the question of infringement. This matter has not been squarely met by the defendants. The complainants' bill alleges, and their experts testify in the opening papers, that the instrument used by the defendants consists of a microphone transmitter, and a magneto receiver which has been decided in the Spencer and Molecular cases to be an infringement. The defendants in their answer (unsworn to), in a vague and argumentative way, deny infringement.

In their affidavits, they do not attempt to show what they were using at the filing of the bill; but they allege, in affidavits filed pending this motion, that "Defendants' apparatus, as now used, may be more particularly defined as operating in method or principle of operation under the Reis inventions of 1860-4, and under special inventions patented by Randall, May 21, 1878, May 4, 1880, and May 3, 1881." Complainants having filed affidavits showing infringements in this apparatus now used, leave was granted to defendants to file another affidavit stating fully what it is that defendants use. Under this leave an affidavit of C. A. Randall (the sixth in the record), has been filed, which contains much impertinent matter reflecting on counsel and opposing experts, but throws no direct light upon the question; but from the affiant's argument we infer that he means to say that defendants are using the apparatus above referred to. The complainants urge, and their affidavits show, that the instruments of the Randall patent, above referred to, transmit speech by means of the Bell variations of current, and we are disposed to agree with them in this view.

Let the injunction issue.

DON A. PARDEE, *Circuit Judge.*
EDWARD C. BILLINGS, *District Judge.*

Filed May 31, 1886. E. R. HUNT, *Clerk.*

THE $2,000,000 SUIT AGAINST WESTERN UNION.

THE brilliancy of such legal luminaries as ex-senator Conkling, Col. Robert G. Ingersoll, Joseph H. Choate and Judge Dillon is in itself sufficient to attract a large and interested audience at the Supreme Court, where Judge Lawrence and a very intelligent looking jury are patiently listening to the searching questions of the examining counsel. On June 17, the cross-examination of Frederick H. May, recently vice-president and general manager of the American Rapid Telegraph Company, was conducted by Col. Ingersoll. His testimony was such as is very rarely heard in a court of justice.

"How soon did the Bankers and Merchants' company," inquired the Colonel, "begin to show the cloven foot and take down the American Rapid signs?"

"I don't know," replied the witness, "about the cloven foot, but the taking down of the signs began in October. Blanks of the Bankers and Merchants' company began to be used at the same time."

"How much would it cost to build the 1,750 miles of telegraph line called for in the contract of August 28, 1883?"

"Do you mean cash?"

"I mean cash up and no grumbling."

"From $1,000,000 to $1,250,000."

"Don't you think there would be $100,000 profit at those figures?"

"I think there would."

"Don't you think there would be $250,000 profit?"

"You want me to make too much money."

"What would have been a fair rental of the American Rapid company?"

"Five per cent. on the capital."

"Did you vote to give $3,000,000 of American Rapid bonds to the Bankers and Merchants' company for building 1,750 miles of telegraph lines?"

"I did."

"Knowing that the building of such lines would cost $1,250,000, you deliberately gave away 1,750,000?"

"I did."

"After the Bankers and Merchants' took control under the contract of October 18, 1883," was among other questions asked, "did you not make a report to the bondholders?"

"I did."

"Did you not report that the new system was being preferred to the Western Union?"

"I did."

"Was it true?"

"I wrote my report from the reports made to me."

"Was it read in your presence or did you slip off?"

"I did not slip off."

"Did you not see," was asked later on, "the draft of a contract made by the Empire Construction Company with the Bankers and Merchants' company under which the construction company was to construct some telegraph lines for the Bankers and Merchants' company, and to be paid between $700 and $800 a mile in Bankers and Merchants' bonds?"

"I did, sir."

"Were those the $10,000,000 bonds?"

"They were the $3,000,000 bonds, a second lien."

"What did you think of that second lien?"

"It looked very slim."

"Very shadowy, I suppose," continued Colonel Ingersoll, "a sort of mortgage on a cloud?"

"It was," explained Mr May, "what Senator Conkling called the other day ten acres of sky."

"In other words," added Colonel Ingersoll, "a land warrant on space."

"In May or June, 1884, after the failure of Mr. Dimock, did you not borrow in Boston $45,000 on bonds of the Bankers and Merchants' company?" asked Colonel Ingersoll after Mr May had stated that the bonds of the Bankers and Merchants' company were comparatively worthless.

"I did," was the answer.

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"And you borrowed the money of your friends, I suppose?"

"I did, sir."

"Is that the way you treat your friends—borrow money of them on worthless collateral?"

"I was acting as a friend of the Bankers and Merchants' company."

"After the cutting of the wires," asked Colonel Ingersoll, with energetic emphasis, "did you not say you was even with somebody?"

"I did," was the prompt and equally energetic response, "I said I was even with that fellow, Stokes" (pointing to Mr. Edward S. Stokes).

"Did you not say that you brought Jay Gould and Mr. Harland, the receiver of the American Rapid, together?"

"I might have said so."

"Did you not brag about having brought them together?"

"Very likely."

"When did you bring them together in point of fact?"

"I saw Mr. Gould, and he said he would meet Mr. Harland at Mr. Conner's office, and it was there they first met."

"When was the meeting?"

"On June 29, 1885."

"Did they meet again?"

"Subsequently Mr. Gould came into Dr. Green's office in the Western Union Building when Mr. Harland and Colonel Wilson, his counsel, and I were there. General Eckert was also there."

"Did you see Mr Gould yourself in relation to the leasing of the American Rapid lines to the Western Union?"

"I did once or twice."

"How many affidavits have you made in these proceedings?"

"Now you have got me. I have made a good many."

"Have you attended at all the suits?"

"I have been generally on hand."

Mr. Choate resumed his direct examination, but even under his adroit leadership the witness made a very poor showing in trying to clear up some of his confused statements.

On June 23d Gen. Edward Harland, receiver of the American Rapid Telegraph Company, was the principal witness. Of all the testimony thus far submitted on behalf of the Western Union his appears to be the most damaging. To say nothing of Gen. Harland's queer ideas upon the best methods for protecting the interests of stockholders of the company of which he was appointed receiver, more conclusive proof could not be wanted of the "deal" by which the Western Union obtained possession of the property, and thus took another of its characteristic advance strides in its persistent efforts to strangle all competition. In answer to Mr. Joseph H. Choate, he stated that he was appointed on the 18th of April, 1885, by Judge Shipman, at Hartford, receiver of the American Rapid company's property. All the property he found was some minute books of the directors and stockholders, obtained from the sheriff, who had taken them on attachment. The telegraph lines of the company were in the possession of Gen. Farnsworth, receiver of the Bankers and Merchants' Telegraph Company.

"Did you ever demand from Gen. Farnsworth," he was asked, "the transfer of the lines to your custody?"

"I did not," he replied.

In the continuation of his direct testimony he stated that he filed "the Harland bill" on the 2d of June last, against Receiver Farnsworth, the object being to obtain possession of the American Rapid property in the latter's possession. After his receivership he cast about to see if there was any way of making the property beneficial to the bondholders. His efforts finally resulted in a contract with the Western Union, under which this corporation was to take control of the property and pay $5,000 a year. He said further that he first talked with Jay Gould about the matter, but denied most positively that he had ever taken a trip with Mr. Gould on his steam yacht. At the meetings held in the Western Union building to perfect the preliminaries of the contract, there were present Jay Gould, President Norvin Green, Gen. Eckert, Mr. Van Horn and ex-Judge Dillon. Finally, on the 10th of last July, the terms of the contract were satisfactorily adjusted and signed. Having affixed his autograph to the important document, he went to look after the sale at auction, advertised at noon on that day, of the Bankers and Merchants' Telegraph property, which, however, did not take place, and he then went to his home at Norwich, Conn. He had no participation in the cutting of the wires, and gave no direction as to taking possession of the property.

"When you were appointed receiver of the American Rapid company," began Col. Ingersoll in his cross-examination, "in whose custody was the property?"

"Of Gen. Farnsworth, receiver of the Bankers and Merchants' company," was the response.

"And you never asked to have the property transferred to you, or authorized any one to make the demand for you?"

"Never."

"In whose interest have you acted as receiver?"

"The bondholders'."

"When Judge Shipman, in his order appointing you receiver, put in something about the interest of the stockholders—that, I suppose, was a waste of breath?"

"I suppose it was simply the usual phraseology."

Gen. Harland, in answer to further questions by Col. Ingersoll, recollected the correspondence between Mr. Edward Lauterbach and himself in regard to the proposition of Mr. Edward S. Stokes and Alfred Sully to lease the American Rapid lines, and to pay more than any one else. He also remembered that such proposition was accompanied with a request not to dispose of the property to other parties without first letting them know, so that they might have the option of making a higher bid.

"You made your contract with the Western Union," continued Col. Ingersoll, with an effective earnestness in his inquiries that startled all present, "with no regard to any other parties?"

"I did not propose to let anybody else know what I was doing."

"Your idea was to keep the matter absolutely private?"

"It was."

"Did you go to the Baltimore and Ohio Telegraph Company and see if it would not make better terms?"

"No, sir."

"Or to the Postal company?"

"I did not go about hawking this property."

"You asked nobody else what they would give?"

"I did not."

"All your efforts, then, for the best interests of the bondholders were with Jay Gould?"

"I did not believe any better offer would be made."

"If the Baltimore and Ohio company had offered you $70,000 a year for the property, what would you have done?"

"I would have snapped up the offer."

"How do you know it would not have given it?"

"I don't know."

"You don't know anything about what anybody else would have given you, except Jay Gould?"

"I don't think anybody else would have given over $60,000 a year."

"Did you know Jay Gould before making this contract?"

"I did not."

"You had heard of him?"

"I had.

"And when you heard he wanted to see you you trotted right down to Mr. Connor's office?"

"I walked down."

"I guess you trotted part of the way. And as soon as you got Gould's offer you corked yourself right up."

"As tight as I could."

"I have no doubt of that: but was that the way to get the highest bid?"

"I did not believe it possible I would get a higher bid."

"Don't you know that the best way to get the highest bid is to let no one know that bids have been made—or are you not familiar with this new philosophy in auctioneering?"

"I took it for granted no one would bid more."

"When you got Gould's bid it kind of paralyzed you?"

"Well, it did; it was equivalent to 2 per cent. on the bonds."

Mr. Hamilton Wallace, one of Gen. Harland's counsel, was next examined. He drew the contract and advised Gen. Harland as to its terms.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—SPECIAL MEETING.

The legislation at the recent annual meeting in the direction of providing for more frequent gatherings, has already been productive of good results. The committee appointed made arrangements for a dinner and special meeting at d'Orville's dining rooms at the Mills Building on the evening of June 8th. The council met at 5 o'clock, and adjourned before dinner was announced at 6.30. Twenty-six members and guests then sat down to a bountiful repast which was served in a most satisfactory manner. After coffee, the meeting was called to order by the president, who announced that Mr. Byllesby had been so fully occupied with very important business matters that he had been unable to prepare his proposed paper on "Incandescent Lighting from Central Stations," but Dr. Otto A. Moses had kindly responded to an invitation to open the discussion, although at exceedingly short notice.

Dr. Moses followed with an address, in his naturally graceful style, in which he pleasantly and clearly presented to his hearers many interesting scientific problems for solution at their leisure. The direct technical subject assumes a fascinating guise under his skilful manipulation, and he was listened to with interest even by the reporters of the daily press, who are by no means susceptible to the hidden beauties of scientific research.

The subsequent discussion was not only very interesting, but it developed the fact that our American electricians are fully alive to the possibilities of the future. The proceedings were reported in full by H. H. Sherman, stenographer, and will doubtless attract considerable attention when published.

Mr. Sidney F. Shelbourne presented a supplementary paper, for consideration, in connection with the subject of retardation,

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which was alluded to in his paper on "Underground Electrical Systems," read before the general meeting, May 19.

The meeting adjourned at 10.30 P. M., having been prolonged somewhat beyond the time originally suggested. This being the first meeting of the kind held by the Institute, it was exceedingly gratifying to the committee to see that the plan was generally approved, and it is believed that hereafter such social-scientific gatherings may be so arranged as to awaken unusual interest in electrical investigation.

The following gentlemen were present:

Bernard, C. G.—New York.	Martin, T. C.—New York.
Callender, G. F. and friend.	Michaelis, Capt. O. E.—Troy, N. Y.
Cleveland, W. B—Cleveland, O.	Mailloux, C. O.—New York.
Cuttriss, Charles.—New York.	Pope, F. L.—New York.
Davis, Minor M.—New York.	Pope, R. W.—New York.
Hamilton, G. A.—New York.	Rapieff, Capt.—Russian Navy.
Knudson, A. A.—New York.	Smith, Gerritt.—New York.
Lockwood, Thomas D.—Boston, Mass.	Shelbourne, Sidney F.—New York.
Millis, John Lieut.—New York.	Seely, J. A.—New York.
Mansfield, Geo. W.—Jersey City, N. J.	Sherman, H. H. (stenographer.—N. Y.
Mitchell, John Murray—New York.	Ward, Henry H. and friend.—N. Y.
Moses, Dr. Otto A.—New York.	Wetzler, Joseph.—New York.

THE EDISON MACHINE WORKS TO LOCATE AT SCHENECTADY.

Nearly all the men employed in the Edison machine shops, 104 Goerck street, this city, and 18 to 24 Bridge street, Brooklyn, recently revolted against the contract system, and demanded nine hours' work with ten hours' pay. The company refused to accede to their demands, and they struck. Treasurer Charles Batchelor says the strike prevented the company from finishing three government torpedo boats within the time agreed upon, thus causing them a heavy loss, and also seriously impeded work on other important contracts. The company compromised with the men, and they returned to work, the company agreeing to give ten hours' pay for nine hours' work.

Since this settlement the Edison company has been looking around for a new place for its machine shops, somewhere away from the influence of labor organizations, where it might build up a little colony of workmen in whom it could place absolute confidence, and where the probability of a strike would be small. The company thinks it has found this place in Schenectady. It has purchased ten acres of land there from the receiver of the McQueen Locomotive Company, and the transfer of the title has already been made. The McQueen company had erected two big shops before it got into difficulties, and these will be occupied by the Edison company's machine works.

"We intended before we had this trouble with our men," said Mr. Batchelor, "to erect our shops on a block of land we had bought in Brooklyn. Architect Post had all the plans ready and the bids for building the shops were all in. Now we will have to sacrifice our Brooklyn land. We probably will have all our machinery transferred to Schenectady before the winter. The casting works in Brooklyn will be operated for a short time, and then they also will be removed.

"Probably between 700 and 1,000 men will be employed in the Schenectady works. We expect to pay less money for labor there, as living is cheaper. Our men now get from $2 to $3.25. The wages we will pay in Schenectady will be from $1.60 to $2.25, and we have no doubt that we can get all the workmen we need at those rates. We will have the new works in Schenectady running inside of six weeks."

STOCK EXCHANGE TACTICS.

Since the New York Stock Exchange took charge of the reporting of quotations from the floor, the Gold and Stock, and the Commercial Telegram companies have been placed on an equal footing. Through their influence with these companies the Exchange authorities have endeavored to prevent the bucket-shops from obtaining quotations through the medium of the instruments of either company. In this they have not been wholly successful. A project is said to have been devised by which the quotations would be furnished to members of the Exchange only, a few minutes in advance of their being distributed to the public. President Anderson, of the Commercial company, had reason to believe that the Gold and Stock Telegraph Company was to be awarded the privilege of this exclusive service, and has applied for an injunction to prevent any such limited contract being made. It is extremely doubtful whether such action will prove beneficial to its future relations with the Exchange, as even if successful, means of retaliation will be found which cannot be reached by legal process, that will be exceedingly detrimental to the welfare of the company.

TELEGRAPHERS JOIN THE KNIGHTS OF LABOR.

Mr. Thomas O'Reilly, who has just been re-elected president of the Telegraphers' Union, says that he shall not start on his general tour all over the country before the 1st of July. He will go to every city as far west as California, and all over Canada where there are councils. He said, furthermore, that it was quite true that the Telegraphers' Union had gone over in a body to the Knights of Labor, although they maintain their distinct organization, of course. This action was taken on the 12th of last month, at the national convention in Missouri, where representatives from over 100 councils were present.

DEATH OF DAVID VAN NOSTRAND.

David Van Nostrand, the well-known publisher, died at his house, No. 23 West Twentieth street, June 14. His health had been feeble for a year, and he had been confined to his house since January. Severe dyspepsia, with complications of other diseases, caused his death.

Mr. Van Nostrand was the most extensive publisher and dealer in electrical books in this country, his business being almost exclusively devoted to all classes of scientific literature.

ELECTRIC LIGHT AND POWER.

The Westinghouse Electric Company are installing two central stations in Pittsburgh and Alleghany, for 1,000 lights each for the Alleghany County Electric Light Company, and a 1,000 light station in Trenton, N. J., for the Trenton Electrical Light and Power Company. The contracts for the whole plant are in the hands of Westinghouse, Church, Kerr & Co. This company has closed contracts for a central station of 1,200 lights of sixteen candle-power at Schenectady, N. Y., and for 1,500 lights for the Keystone Electric Company, Philadelphia.

The firm of Grace & Co., of which the present Mayor of New York city is a member, have formed an association in Valparaiso to establish the Edison electric light system there.

The building committee of the West hotel at Minneapolis are investigating the workings of the different light systems of that city. They propose to light the hotel by electricity.

The Detroit Electric Light Tower Company has had an ordinance introduced into the council of Columbus, O. Accompanying the ordinance was a copy of the contract the company proposes to make with the city. It contemplates forty-three towers, each having four lamps of 200 candle-power. The price to be paid by the city is $3,958.30 per month. The ordinance gives the company authority to tear up the streets and alleys in order to lay underground wires, etc., and to furnish electricity for light, heat, power and other purposes.

The Jarvis Engineering Company, of Boston, has sold the second Armington-Sims Company engine to the Brookline (Mass.) Electric Light Company. They will double the number of their lights, as the system is very popular in that town. They use coke screenings from the gas company for fuel.

The Rutland Electric Lighting Company, Rutland, Vt., has voted to increase its capital stock from $5,000 to $50,000, for the purpose of putting in an extensive plant for lighting the entire village. This company will buy two engines of 125 and 75 h p.

The Electric Light and Patent Flooring Company, Salisbury, Mass. Capital stock, $20,500. Robert Drummond, and others, incorporators.

Spencer & Mack, Grand Rapids, Mich., will add another plant.

The Edison Illuminating Company, Detroit, Mich. Capital stock, $250,000. E. W. Voigt, 203 Grand River avenue, and others, incorporators.

The Merchants' Electric Illuminating and Power Company, of Galesburg, has been incorporated. Capital stock, $20,000. R. H. Whiting, Howard Knowles, and J. K. Mitchell, incorporators.

The Business Men's Electric Light Association, of Joliet, Ill., has been incorporated. Capital stock, $20,000. J. O. Gorman Jr., J. D. Paige, J. C. Barrett, G. L. Vance, and others, incorporators.

The value of incandescent electric lights for subaqueous work was recently tested in a practical and interesting way at the Poynton colliery, near Stockport, England. The lower pump rod of the main pumping shaft, by means of which the shaft was drained, broke, leaving the bucket in the bottom, about 600 feet below, and submerged. To repair this divers were employed, and the work was carried on by the light of an electric lantern operated by a primary battery. A light of about 80 c. p. was obtained, and an area of about 12 feet square was illuminated. By this light the repairs are successfully made.

The Edison incandescent plant established by Dr. Cloud at Jacksonville, Fla., has been recently sold to a new company, under the title of the American Electric Illuminating Company. The Citizens' Gas Light Company is largely interested in the new corporation.

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PERSONAL MENTION.

Mr. Chas. A. Schieren, of New York, manufacturer of electric leather belting, sailed on June 5th for Europe, and will be absent several months.

Mr. J. H. Bunnell has returned from a European trip in good health, and has profitably occupied his time in looking into the electrical business methods of the old world.

Captain O. E. Michaelis, U. S. A., who is stationed at Watervliet arsenal, gave an interesting lecture on the measurement of the velocity of projectiles, at the Winslow laboratory on Monday evening, May 31st. A large number of professors and students attended. After speaking highly of the engineering ability of graduates of the Rensselaer Polytechnic Institute, the captain began his lecture by a description of the earliest form of velocimeter, and thence traced its evolution through successive stages and improvements to the most modern form, a machine that will measure down to the $\frac{1}{100000}$ part of a second of time.

In recognition of the great advance exhibited in Mr. Lucius J. Phelps's method of communicating telegraphically with moving trains, the Franklin Institute has awarded to that gentleman the John Scott medal and prize.

THE TELEGRAPH.

The total length of the Italian telegraph lines at the close of last year was 18,655 miles, an increase of 833 kilometres, and on the same date the total length of telegraph wires was 106,755 kilometres (66,337 miles).

The Baltimore & Ohio Telegraph Company's new northwestern extensions are reported almost ready for business. The lines over the Wisconsin Central route, and extending to Chicago, St. Paul and Minneapolis, are said to be practically ready for operation.

THE TELEPHONE.

In the case of the American Bell Telephone Company against the Long Telephone Company, a motion for preliminary injunction was argued at Parkersburg, W. Va., June 23, before Judge Bond. The defendants were represented by Jeff Chandler, of Washington. Mr. Chandler took the position that the government suit operated to cast such doubt upon the validity of the Bell patents that no injunction should issue during the pendency of that suit. Judge Bond overruled this point and held that the government suit had no bearing upon this case, and ordered an injunction for the complainants as prayed for.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICIAN AND ELECTRICAL ENGINEER, *by* Pope & Edgecomb, *Solicitors of Patents for Electrical Inventions*, 11 *Wall Street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From April 13th to June 15th, 1886 (inclusive).

Alarms and Signals:—*Hotel Annunciator and Fire Alarm*, A. T. Hess, re-issue 10,711, April 13; 341,909, May 18. *District Signaling Apparatus*, J. C. Wilson, 339,960, April 13. *Police Signal System*, L. B. Firman, 340,208, April 20. *Automatic Alarm Apparatus*, C. L. Horack, 340,441. *Fire Alarm Apparatus*, C. D. Rogers, 340,618, April 27. *Signaling Apparatus*, T. A. Edison, 340,708. W. J. Dudley, 342,340, May 25. *Thermostat*, J. A. Miller, 340,890, April 27. *Thermo Damper Regulator and Alarm*, A. M. Butz, 341,092, May 4. *Fire Alarm Telegraph*, J. C. Wilson, 341,114, 341,115, May 4. *Push Button*, S. Vanstone, 341,298. *High and Low Water Alarm*, E. K. Rollins, 341,694, May 11. *Barometer for Indicating Fire Damp*, R. R. V Walcher-Uysdal, 341,822. *Indicator for Electric Circuits*, O. F. Jonsson, 341,918, May 18. *Watchman's Time Recorder*, C. W. Holtzer, 342,013. *Current Indicator*, F. A. Swan, 342,475, May 25. *Prison Vault and Safe Alarm*, J. W. Ruenzi, 342,709. *Signal Call Box*, J. E. Smith, 343,738, June 15. *Alarm Apparatus*, W. C. Smith, 343,863. *Burglar Alarm*, J. Tomney, 343,868, 343,869.

Clocks:—*Synchronizing Device*, C. H. Pond, 339,688, April 13; J. S. Ross, 341,111, May 4. *Clock and System*, J. E. Carey, 341,449, May 11. *Winding and Controlling System*, same, 341,450. *Pendulum Clock*, O. & F. Haenichen, re-issue, 10,720, May 11, 342,086, May 18. *Gas Electric Advertiser Clock*, L. Lenaerts and H. L'Olivier, 341,926. *Clock Movement*, P. Lange, 343,976, June 15.

Commutators:—E. Thomson, 339,714, April 13. E. Weston, 340,401, April 20. A. Bernstein, 343,266, June 8. S. Bergmann, 341,723, May 11. *Cut-out*, J. M. Fairchild, 340,868, April 27. A. Lungen, 341,384, May 4.

Conductors, Insulators, Supports and Systems:—*Underground Conduit*, J. Beeler, 339,844, April 13; D. N. Hurlbut, 340,046; D. H. Dorsett, 340,431, 340,432, 340,433, April 20; J. R. Burdick, 342,280, May 18; A. Wyckoff, 343,354, June 8; G. S. Hull, 343,458. *Insulating Composition*, J. Howe, 339,777, April 13; E. D. Kendall, 339,787. *System for Lighting*, E. Weston, 340,404, April 20. *Chimney Support for Wires*, 340,520. *Suspending Device for Lamps*, P. Krautz, 340,512. *Multiple Series System of Distribution*, A. J. Holt, 340,717. April 27. *Insulator*, B. Seabolt, 340,734; E. C. Blake and E. C. Trunnell, 342,320, May 25; A. Brandon, 342,324. *Insulating Wires*, D. Brooks, Jr., 340,931, April 27; F. R. Hoard, 342,694, May 25. *Light System*, W. M. Schlesinger, 341,059, May 4; J. H. R. Ward and W. J. Jenks, 342,549, May 25. *System of Distribution*, G. Westinghouse, Jr., 342,552, May 25. J. W. Howell, 342,748; T. A. Edison, 343,017, June 1. *Conductor for Mechanical Telephone*, H. Seligman, 342,468, May 25. *Compound Cable*, H. W. Libbey, 342,523. *Conductor*, E. G. Acheson, 342,892, June 1. *Process of Making Cables*, J. J. C. and M. Smith, 343,081. *Multiple Cable*, same, 343,082. *Manufacture of Cables*, J. J. C. Smith, 343,083. *Vulcanizing Insulation*, M. Smith, 343,084, *House Wiring for Lights*, L. Stieringer and J. H. Vail, 343,087. *Process of Manufacturing Conductors*, E. G. Acheson, 343,099. *Communicating System*, A. G. Holcombe, 343,374, June 8. *Distribution of Energy*, G. and A. Pfannkuche, 343,603, June 15. *Cable*, S. F. Shelbourne, 343,676.

Dynamo Machines and Motors:—*Unipolar Dynamo*, C. Hering, 339,772, April 13. S. C. De Ferranti, 341,097, May 4. *Dynamos*, C. Batchelor and H. E. Walter, 339,839, April 13. E. Weston, 340,395, April 20. R. Eickemeyer, 342,504, 342,5~7, 342,588, 342,589, May 25. C. Batchelor, 341,990, May 18. A. G. Ketchum, 343,129, June 1. S. H. Tacy, 343,930, June 15. *Commutator for*, T. E. Adams, 340,537, April 27. *Brush shifter for*, E. H. Amet, 340,539. *Steam Dynamos*, L. G. Woolly, 341,803, May 4. *Holder for Commutator Brushes*, C. D. Jenney, 342,441, May 25. *Compensating Resistance for Dynamo*, C. Hering, 339,773, April 13. *Stopping Device for Motor*, E. Leigh and T. Townend, 342,87~, June 1. *Motor*, E. T. and D. Higham, 343,176, June 8. J. Doyle, 343,444, H. M. Paine, 343,487. *System for Regulating and Controlling Motors*, J. M. Pendleton, 343,393, 343,394. *Governor for Motor*, C. F. Brush, 343,886, June 15.

Electrolysis:—*Apparatus for Electrotyping*, W. L. Ladd, 339,431, April 6.

Galvanic Batteries:—*Battery and means for Emptying and Recharging*, J. T. Armstrong, 340,474, April 20. *Manufacture of Rubber Battery Cells*, J. W. Carter, Jr., 341,552, May 11. *Galvanic Battery*, A. C. Harris, 341,907, May 18. H. Walter, 342,457, May 25. E. M. Gardner, 342,~08.

Ignition:—*Shell Fuse*, E. L. Zalinski, 341,536, May 11. *Method of Firing Torpedoes*, same, 341,537. *Gas Lighting Apparatus*, A. F. Cogswell, W. Young and J. R. Holdeman, 341,882, May 18. J. Finck, 341,565, May 11. *Automatic Gas Lighter*, same, 341,566.

Lamps and Appurtenances:—*Arc Lamps*, D. B. Macdonald and H. W. Woodman, 339,905, April 13; L. G. Woolley, 340,182, April 20; O. A. Moses, 343,-188, June 8; O. F. Jonsson, 343,242; V. V. Golitzinsky, and P. O. Rymascheffski, 343,511, June 15. *Carbon Holder for Arc Lamp*, S. H. Stupakoff, 340,065, April 13. *Incandescent Lamp*, E. Weston, 340,396, April 20; T. A. Edison, 341,644, 341,839, May 11; L. Stieringer, 341,778; L. J. Crossley and J. J. Hicks, 341,997, May 18. *Holder for*, E. Weston, 340,400, April 20; L. G. Woolley, 341,620, May 11; L. Heinze, 343,313, June 8. *Manufacture of Carbon Conductors for Incandescent Lamps*, E. Weston, 340,397, April 20. *Process of making Incandescents*, same, 340,402. *Cut-out Instrument for Incandescent Lamps*, F. P. Little and W. H. McDonald, 340,448.

Measurement:—*Apparatus for Measuring Currents*, P. Cardew, 342,777, June 1. *Meter*, J. R. Grove, 343,450, June 8.

Metallurgy:—*Apparatus for Extraction of Precious Metals from Ores*, D. W. Birmingham, 342,421, May 25.

Miscellaneous:—*Attachment for Exhibiting Devices*, W. T. Smith, 339,706, April 13. *Combined Spatula and Mouth Illuminator*, A. R. S. Foote, 339,-754. *Governor for Steam Engines*, A. O. Tengvall, 339,836. *Device for Operating Valves*, F. A. Hinds, 339,888. *Apparatus for Producing High Vacuums*, A. L. Reinmann and C. G. Ott, 339,930. *Rheostat*, F. P. Little and W. H. McDonald, 340,449, April 20; E. Weston, 340,398. *Indicator*, same, 340,399. *Current Indicator*, same, 340,403; E. H. Amet, 340,538, April 27. *Belt*, M. Payne and D. Benson, 340,815; G. A. Wright, 343,620, June 15. *Mariner's Compass*, E. Bisson, 341,125, May 4. *Connection*, G. D. Burton, 341,128. *Reproducing Sounds from Phonograph Records*, A. G. Bell, S. Tainter and C. A. Bell, 341,212. *Transmitting and Recording Sounds by Radiant Energy*, same, 341,213. *Recording and Reproducing Speech and Other Sounds*, C. A. Bell and S. Tainter, 341,214. *Recording and Reproducing Sounds*, S. Tainter, 341,287. *Apparatus for same*, 341,288. *Safety Device for Wires*, E. B. Temple, 341,289. *Steam Governor*, E. H. Amet, 341,368. *Exercising Apparatus*, W. T. McGinnis, 341,593, May, 11. *Apparatus for Aging Liquors*, S. G. Cabell, 341,727. *Laryngoscope*, B. H. Bayles, 341,873, May 18. *Armature for Magnet*, O. C. Woolson, 341,981. *Valve*, W. S. Johnson, 342,018; A. S. Kissell, 343,642, June 15. *Machine for Covering Wire*, W. D. Grimshaw, 342,085, May 18. *Thermostatic Circuit Controlling Device*, M. Martin, 342,114. *Device for Making and Breaking Circuit*, V. Willis, 342,157. *Driving Mechanism for Suspended Cars*, J. A. Enos, 342,246. *Circuit-Testing Chronograph*, J. A. Tilden, 342,481, May 25. *Apparatus for Flushing Water Closets*, A. A. Barker, 342,495. *Induction Coil*, G. Westinghouse, Jr., 342,553; A. M. A. Beale, 342,947, June 1; G. and A. Pfannkuche, 343,602, June 15. *Transmitter*, J. T. Williams, 342,666, May 25. *Connecting Device*, E. H. Johnson, 342,751. *Device for Controlling the Movement of Armatures for Electro-magnets*, C. L. Clarke, 343,008, June 1. *Automatic Regulator for Incubators, etc.*, P. C. Morse, 343,058. *Automatic Billiard Register*, J. J. Gleason, 343,169. *Wire Splicer*, F. S. Pearson, 343,-194, June 8. *Electro-Magnet*, E. B. Cutten, 343,227. *Mechanism for Transporting Goods, etc.*, F. Jenkin, 343,319. *Ball Ornament for Lightning Rods*, 343,332. *Circuit-Closer*, H. H. Hoffman, 343,372. *Reverse Current Interceptor*, A. G. Holcombe, 343,373. *Coupler*, G. D. Burton, 343,515. *Fence*, D. H. Wilson, 343,939. June 15.

Railways and Appliances:—*Circuit for Railways*, S. H. Short and J. W. Nesmith, 339,942, April 13. *Bell Cord*, H. B. Cox, 340,425, April 20. *Coupling for*, same, 340,426. *Railway*, E. W. Siemens, 340,462; F. J. Sprague, 340,684. April 27, 340,685; S. H. Short, 343,076, June 1; E. M. Bentley, 343,101, 343,884, June 15. *Railway System*, S. Miller, 343,719. *Switch for Electric Railway*, W. M. Schlesinger, 341,058, May 4. *Track Instrument*, C. D. Tisdale, 341,291, May 4. *Alarm for Torpedo Railway Signals*, H. F. Clark, 341,553, May 11. *Railway Signal*, G. F. Carlile, 340,698, April 27; W. W. Le Grande, 341,666, May 11. *Railway Signaling*, W. C. Crandell, 342,499, May 25. *Elevated Railway Structure*, J. H. Pendleton, 342,459. *Railway Telegraph*, C. W. Williams, 343,095, June 1.

Secondary Batteries:—J. Pitkin, 341,600, May 11: C. Sorley, 341,860; W. H. Remington, 342,385, May 25; C. D. F. Gibson, 342,594. *System for Controlling Secondary Battery Circuits*, J. M. Pendleton, 343,392, June 8.

Telegraphs:—*Convertible Key*, J. A. Moloney, 339,909, April 13; 343,469, June 8. *Quadruplex*, J. W. Larish, 340,130, April 20. *Key*, R. A. Macready, 340,134, April 20; Geo. F. Thomson, 343,742, June 15. *Local Circuit for Quadruplex*, W. Maver, Jr., 340,136, April 20. *Branch Circuit for Quadruplex*, same, 340,137. *Transmitter for Printing Telegraphs*, C. L. Healy, 341,654, May 11. *Printing Telegraph*, same, 341,655, 341,656. *Relay*, S. A. Chase, 342,576, May 25. *Automatic Printing Telegraph*, E. J. Mallett, 343,042, June 1. *Automatic Telegraphy*, same, 343,043, 343,044. *Sounder*, J. A. Maloney, 343,068, *Dynamo Telegraphy*, June 8. S. D. Field, 343,953, June 15.

Telephone Systems and Apparatus:—*System of Communication*, T. B. Doolittle, 339,625, April 13. *Switchboard and Central Office Apparatus*, same, 339,626. *Combined Annunciator and Spring Jack*, same, 339,627. *Short Circuiting Device for Magneto Calls*, G. A. Mason, 339,672, April 13. *Individual Signal*, E. P. Warner, 339,718. *Transmitter*, D. Drawbaugh, 339,745; E. Berliner, 340,853, April 27; E. H. Johnson, 341,579, May 11; J. F. McLaughlin, 341,263, 341,264, May 4; A. Beale, 342,775, June 1. *Telephonic Apparatus*, H. N. Hastings, 339,766, April 13. *Switch*, J. A. Blattan and G. A. Boyden, 340,028. *Repeater*, T. A. Edison, 340,707, April 27. *Circuit*, T. A. Edison and E. T. Gilliland, 340,709. *Signaling and Switching System*, G. H. Glass and W. Clark, 340,911. *Circuit-breaker for Telephone Lines*, same, 340,912. *Telephone*, J. T. Guthrie, 341,000, May 4; J. F. McLaughlin, 343,334, June 8; E. T. Gilliland, 343,449. *Time System for Telephone Lines*, J. S. Ross, 341,110, May 4. *Telephone Receiver and Circuit*, W. Marshall, 341,359. *Magneto Telephonic Apparatus*, F. H. Brown, 341,370. *Instrument for Transmitting Vocal Sounds*, C. J. Stuart, 341,519, May 11. *Mechanical Telephone*, G. F. Shaver, 342,395, May 25. *Auxiliary Mouthpiece for Telephone*, N. A. Tauner, 342,477. *Induction Telephone Repeater*, S. F. Shelbourne, 342,881, June 1. *Means for Preventing Disturbances on Telephone Lines*, J. E. Dann and J. Lapp, 343,014.

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THE ELECTRICIAN AND ELECTRICAL ENGINEER.

Conducted by F. L. POPE. G. M. PHELPS, JR., R. W. POPE, } Associate Editors.

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NEW YORK, AUGUST, 1886.

THE WORK OF THE SUBWAY COMMISSION.

TWELVE months have passed by since the organization of the New York Commission on Electrical Subways, and while it is unquestionably the fact that there are more wires overhead to-day than there were at that time, substantial progress has been made in settling upon a plan of operations, and there is apparently no reason to doubt that several miles of conduit will be laid down before winter sets in. The methods pursued by the commission in investigating this complex subject have been carefully watched by a host of rival inventors, whose anxiety as to the character of the final decision, indicated that its importance was by them at least, thoroughly appreciated.

Comparatively little subterranean electrical work of any kind has been done in this country, and this being the first undertaking in the world of so great magnitude in the way of electrical underground construction, it was evident that unusual care was essential to avoid mistakes, which might lead to subsequent annoyance and expense. So far as can be judged by the report submitted, the commission has conscientiously examined all the plans which have been presented, and listened attentively to such oral explanations as were deemed necessary to be given by the representatives of the various inventors. The merits of but comparatively few had been demonstrated by practical use, and those which were found in actual service fell far short of meeting the manifold requirements of an ideal system which could be recommended for adoption in New York city. Having waited the prescribed time for the various electrical companies to file their plans, and for inventors and others to present such devices as they deemed proper, the commission went into executive session, and in accordance with the law proceeded itself to devise a system. The various drawings, specifications and models, were submitted to a mechanical expert, who finally prepared the plans of a system embracing the best and most essential features of the several ideas presented. The law was interpreted as being intended to provide a subway, through which the various companies should draw such insulated wires or cables as they might consider best adapted for their service, and consequently a conduit or "hole through the ground" was deemed a necessary part of the system. The material recommended for the construction of this conduit was asphaltum concrete, in direct opposition to the views of a number of interests which advocated cast iron. Electrically there is a wide difference between them, one being an insulator, and the other a conductor. The conflict between the advocates of the rival materials finally reached a stage where members of the commission appeared to doubt not only their own opinions, but the views of every one else, and serious reflections upon the capacity of the commissioners began to appear in the daily papers. During this period of uncertainty and before reaching a final decision, President Loew was stricken down with a severe attack of pneumonia which finally terminated fatally. The vacancy in the commission was filled by the appointment of Hon. Roswell P. Flower, who immediately went over the ground which had already been thoroughly examined by his colleagues and predecessor. Having satisfied himself by personal investigation that the existing report of the mechanical expert was a feasible solution of the problem, or at least one which gave promise of meeting the requirements, an additional expert was brought in to make such mechanical and chemical tests of the proposed material, as would settle at once the question of its adaptability for the work in question. A portion of these tests, particularly as regards the effect of steam heat, are embraced in the report of President Flower, printed in full in our news columns.

The plan of laying subterranean wires which had been adopted from English practice by the Western Union Telegraph Co., was the use of gutta-percha insulation, and the drawing of the wires or cables through iron pipes. It was found in practice, however, that the heat radiating from buried steam pipes, passing readily through the iron, destroyed the insulation, and the wires soon became useless. This experience was interpreted as proving that a conduit made of asphaltum concrete would be destroyed by heat. As a matter of fact it now appears upon scientific investigation that actual danger to a conduit from this source is wholly imaginary. While it is true that gutta-percha, melting at a temperature of 90°, became useless as an insulator in an iron pipe, it appears very probable that the same wire under similar conditions protected by a conduit of asphaltum concrete would not have lost its insulation, the material proving to be a very poor conductor of heat. The question of steam heat being disposed of, the strength of the structure and its endurance under the disintegrating effects of New York city soil were taken up, and satisfactorily settled.

The only electrical advantage claimed for iron was its utilization as an induction shield, which is supposed to be an advantage in its bearing upon the telephone service. It appeared, however, that the telephone people did not consider this as of especial benefit to them, and, other things being equal, preferred that the conduit be an insulator.

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It has been observed that the Western Union Telegraph Co. objects to the proposed plan of placing wires in charge of an independent company. In its own case, this is a very natural feeling, as the policy of this company has been to dictate rather than be dictated to. So far as the wires of other companies are concerned, experience goes to show that they will probably be safer under the lock and seal of a responsible conduit company, than on the roofs of such buildings, say, as 187 Broadway.

There has been a vast deal of arrant nonsense talked, written and printed, as to the dangers of overhead wires. This has been instigated in a great measure by parties who imagined that they had a mortgage on future electrical subterranean construction. An exceedingly defective and inoperative statute was finally passed, to which no attention was paid by anybody. The existing commission was appointed with authority to exercise a certain discretion in putting the law in force. Recognizing the fact that the time had arrived when preparations must be made to comply with duly authorized legislation, we have given considerable space and attention to this matter, in the belief that if this work is to be done, it should be done carefully and properly. It is perhaps unfortunate that some of the most earnest advocates of underground legislation, who have devoted time and money to the moulding of public opinion, will fail to reap that substantial reward which is expected to accrue from the rental of conduit privileges. In the near future, however, they may content themselves with the reflection, that although they failed to connect, the wires are underground, and their lives are safe from the dangers which, as they say, have threatened us all these long and weary years.

THE PAN-ELECTRIC SCANDAL.

In our issue of November, 1885, commenting upon the proceedings which had then recently been instituted by certain law officers of the government for the purpose of annulling the Bell telephone patent, we suggested the probability that the real object of such a suit was merely to afford a plausible pretext for the refusal or postponement of injunctions which might be applied for by the American Bell Telephone Company, against infringers pretending to act under the authority of the Pan-Electric organization. The testimony elicited by the Congressional investigating committee, which has been holding an inquest on the subject, is quite sufficient to show that this was actually the case. The decision in the New Orleans suit must, however, have put an end to any hopes which might have been entertained by the projectors of the Pan-Electric and its allied schemes, that the fact of a government suit being pending would serve to shield them from the action of the Circuit courts, and from the penalties of infringement. In fact, the public, or at least that portion of the public of which the Pan-Electric newspaper organs assume to be the mouthpiece, has visibly lost its interest in the outcome of the proceedings, although the peculiar position in which the unfortunate attorney-general of the United States has been left still continues to excite a certain degree of interest and sympathy in political circles. We stated at the time that the indications then were that the whole matter would ultimately become a partisan political issue. This is exactly what has happened. The congressional investigating committee collected a vast mass of testimony, and some of the facts elicited were anything but creditable to the principal persons implicated in the scheme. The outcome of the investigation was eminently characteristic. The four republican members of the committee presented a report, which, although extremely partisan in its character, is nevertheless supported by the testimony. It is very long and very strong, not to say scathing. It refers, in good set terms, to the stock-jobbing proclivities of the attorney-general and his associates. It criticises the administration, and not without justice, for permitting proceedings to be instituted against the Bell patent at the instigation of such parties. The report also pays its respects to certain newspapers which have been prominent in misrepresenting and abusing the Bell telephone company. On the other hand, the report of four of the five democratic members carefully exonerates the attorney-general and his official friends from all blame, and asserts that the evidence fails to show that any of these gentlemen went into the Pan-Electric scheme with an expectation of profiting by their official positions or connections. The remaining democrat preferred to make an individual report, in which he occupies substantially the position which the children, when playing see-saw, used to term the "candle-lighter." He thinks the officials were imprudent, but that they didn't mean any harm. Matters have been so managed that probably no action will be taken on the report during the present session of Congress, and in the meantime, it appears, we are all at liberty to think what we please about it. It is certain, at all events, that the investigating committee, under the energetic chairmanship of Mr. Ranney, have succeeded in unearthing a large quantity of excellent campaign material, which will, no doubt, be used for all it is worth by the republicans, when matters begin to warm up preparatory to the next presidential election. As for attorney-general Garland, it would appear that the proper thing for him to do is to resign, as his persistence in holding on his office under the circumstances leaves the President, who, of course, is reluctant to remove him, in nearly as uncomfortable a predicament as the hunter who had the tiger by the tail, and could not, to save his life, make up his mind whether to hold on or to let go.

ARE ELECTRIC CONDUCTORS PROPERTY?

The Western Union Telegraph Co. is the owner of a property which according to its own valuation is worth no less than eighty millions of dollars, something like two-thirds of this property being represented by 150,000 miles of telegraph line, on which are strung some 500,000 miles of wire. These poles, wires, and fixtures are distributed throughout the entire area of the United States and the territories thereof, on railways, highways and by-ways, and in wildernesses and deserts where there are no ways at all. For the most part this extensive plant is, and from the necessity of the case must ever continue to be, utterly unprotected, other than by that instinctive and universal respect for the property rights of others and for the law of the land, which is inherent in the very nature of the American people. It would naturally be supposed that

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the owners of a frail and perishable plant, lying thus unavoidably exposed, and everywhere utterly at the mercy of any unscrupulous depredator, would be the very last people in the world who would undertake to inaugurate a ruthless and lawless destruction of the very same kind of property, with no apparent shadow of justification, save a wanton and reckless desire to injure and interrupt, by fair means or foul, the business of a competitor. As Napoleon once said of a somewhat analagous undertaking, the destruction of the lines of the Bankers and Merchants' company in July 1885, by order of the general manager of the Western Union company, was one of those acts which are worse than a crime—it was a blunder. Therefore we esteem it a most fortunate circumstance for the stockholders of the Western Union company that a jury has been found who were willing to expressly declare that this arbitrary and riotous piece of vandalism was of a character which is not to be tolerated in a law-abiding community. The establishment of this legal precedent is, in our opinion, worth to the defendant corporation many times the trifling sum of $240,000 which the jury has decided that it ought to pay as a contribution towards the total expense of giving its general manager an elementary legal education. For upon due consideration, it will appear that had the jury affirmed the propriety of the action taken by that functionary, it would necessarily follow that any one of the somewhat numerous persons who imagine themselves more or less aggrieved by the proceedings of the Western Union company, whether managers of competitive companies, striking employés, or what not, by providing himself with a pocket full of dynamite cartridges and a small crowbar wherewith to perforate the ground for the insertion of such cartridges beneath the poles, could in one single night, so effectually wreck the facilities of that corporation at some well-chosen and vital point, that hundreds of thousands of dollars would be insufficient to cover the resulting losses; and, moreover, in the somewhat improbable event of detection, could by the aid of able legal talent, get off scot free, on the ground that telegraph lines, like umbrellas and wild animals, are not within the protection of the statutes and, therefore, not property. It is our candid opinion, that the jury in the Bankers and Merchants' case deserves a most cordial vote of thanks from the stockholders of the Western Union company, but there is too much reason to fear that they will not get it—in fact, not by a large majority.

STOCK QUOTATION SERVICE.

In the interest of a fair field and no favor, we trust that the remarkable scheme for crippling the Commercial Telegram Company, set forth in a morning newspaper of June 23d may prove to have small foundation in fact. It is distinctly alleged that the governing committee of the Stock Exchange is being manipulated in the interest of the Western Union and Gold and Stock Telegraph companies, with a view of ousting the Commercial Telegram Company from the floor of the Exchange.

We cannot believe that the governing committee will deliberately participate in an undertaking which, if successful, would kill off the enterprising company that has done so much to improve and cheapen the service of telegraphic stock reporting. All persons acquainted with the business must admire the practical skill and the enterprise shown in the development and introduction of the system of the newer company. Their success seems to have compelled the Gold and Stock Telegraph Company to redeem their long deferred promises of introducing better machinery, more capable of keeping quotations abreast with the market.

At present we understand that good service is furnished by both companies; and it would seem very obviously in the interest of the Stock Exchange to assist in maintaining the present competition. In undertaking to suppress the "bucket-shop" business the Exchange has attempted to do what is obviously impossible; that is, to prevent the almost instantaneous circulation of its quotations, after they have been transmitted outside of its immediate jurisdiction.

THE WIRE GAUGE QUESTION.

Notwithstanding the favorable legislation of the telephone and electric light associations, looking to the more general adoption of the new English standard wire gauge, there appears to be little disposition on the part of either manufacturers, dealers, or consumers to recognize it in business transactions. Such being the case, it is, of course, impossible to do more than has already been done towards the actual adoption of a standard gauge. There is a growing tendency on the part of all buyers who require exactness in sizes, to give the measurement in mils, a practice which is generally understood, and if sufficiently convenient to suit the parties chiefly interested, it appears to be extremely probable that, instead of approving a standard gauge, practice will gradually obliterate the old method of designating the various sizes by arbitrary numbers. It cannot be denied that the drift of opinion among those who are most familiar with this question is, that misunderstanding as to size can be wholly avoided by stating the actual diameter in thousandths of an inch, while to those who are not so particular, the variations in size, existing between the same numbers, as given by different gauges may not be sufficient to cause annoyance.

What is urgently needed in connection with this much argued question is reform. The particular method by which it is attained is of comparatively little consequence. The first proposition for the adoption of a standard was, we believe, made by a drawer of wire, and it was thought at one time that the sentiment of the manufacturers was in favor of adopting a standard. If they do not approve of the course already pursued there is little use in attempting to force it upon them, unless by the assistance of that questionable process, popularly known as "boycotting." The keen competition now existing between wire dealers will doubtless lead them to furnish any gauge of wire which might be called for by their customers.

The only real advantage in the continuance of the arbitrary scale of numbers, beyond that convenience which is always found in the perpetuation of a trade custom of long standing, is that it enables the manufacturers to keep a stock on hand of certain gauges which experience has shown are most frequently required by consumers. Even this advantage will not, however, wholly disappear with the advent of the new system.

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ARTICLES.

TESTING THE COMMERCIAL EFFICIENCY OF DYNAMO MACHINES.[1]

BY GISBERT KAPP.

One of the main features by which sound scientific engineering is distinguished from mere rule-of-thumb work on the one hand and from abstruse theorizing on the other hand is the application of rigorous methods of measurement to all problems connected with it. Until we know how to accurately measure, and express in well-known physical units, the forces and quantities we have to deal with in any piece of machinery, we cannot hope to thoroughly understand, and much less to improve, that particular piece of machinery. Dynamo machines have for some years past formed the subject of experimental investigation all the world over; and the amount of reliable information which has thus been accumulated is very considerable. Early experimenters labored under the disadvantage that the physical units on which their measurements had to be based were themselves not accurately known; and even the units of the present day are only approximately correct, though the possible error is so exceedingly small that for all practical purposes we may consider the present legal units for resistance, current strength, and electromotive force as absolutely accurate. It is probable that the personal error of observation in reading measuring instruments is greater than the possible error in the accepted value of these fundamental units, and therefore no single reading could be made more accurate, even if the accepted units were absolutely correct. Of course, errors of observation can be greatly reduced by taking a large number of readings and correcting the differences by the method of least squares; and if that be done, the accuracy of our calculations would increase as the real values of the fundamental units became known. But it is never done in practical engineering work. We take as a rule single readings only, or at best the mean between two or three readings, and then the personal error is greater than the possible error in the accepted value of the unit. It is customary to regard 746 watts—that is, the electrical energy represented by a current of one ampère flowing for one minute under a difference of potential of 746 volts—as the electro-dynamic equivalent of 33,000 foot-pounds work done in one minute; in other words, 746 watts represented one horse-power. This value of the electro-dynamic equivalent is deduced as follows: We know that the dyne is that force which accelerates the mass of one gramme by one centimetre in one second. Gravity accelerates the mass of one gramme by g centimetres in one second, and the dyne can therefore be expressed as the product of the weight of one gramme and the ratio of these two accelerations. If we express g in metres per second, we thus find that one dyne equals $\frac{10^5}{g}$ kilograms. This is the unit of force. The unit of energy, the erg, is represented by the force of one dyne acting through a distance of one centimetre, and can be similarly expressed as $\frac{10^7}{g}$ kilogrammetres. Since the unit of current is 10 ampères and the unit of electromotive force 10^{-8} volts, and since the product of the two must be equal to the erg, we find that one watt equals 10^7 ergs, and that one kilogrammetre is equal to $\frac{1}{g}$ watt, and, therefore, 75 kilogrammetres, or one horse-power, is represented by $g \times 75$ watts. Now g, the acceleration of gravity, can be taken at 9.81, and hence $75 \times 9.81 = 736$ is the number of watts representing one horse-power or 75 metre kilograms per second. That is the usual French horse-power of 32,500 foot-pounds. The equivalent of the standard English horse-power of 33,000 foot-pounds would therefore be larger in the proportion as 33 is larger than 32.5. That gives the figure 746 above mentioned.

After these preliminary remarks we may confront our subject a little more closely. In the early days of dynamo machines, efficiency was quite a secondary question, and the output of a machine was hardly ever expressed as so many volt ampères or so many electrical horse-power, but it was simply stated that it could drive, say, three good arc lights, or four lights not quite so good. This was a rough and ready way of describing the machine, and although the output could be approximately guessed from the number of lamps, the size of the carbons, and the brilliancy of the arcs, nobody could form the least opinion on the question of power absorbed, even if he cared for it, which might be doubted. As long as the dynamo could be kept running, and as long as some light was produced, it was considered satisfactory.

The question of efficiency was first broached in connection with the electric transmission of power, but it was brought forward in a somewhat misleading way. In all probability, M. Marcel Deprez is to a great extent responsible for the loose way most electricians got into when talking about the efficiency of dynamos, and for the many absurd statements relating to the transmission of energy by dynamo machinery which are found in many of our best standard text-books. M. Marcel Deprez, in his lecture delivered at the Paris congress of electricians in 1878, and after him nearly every writer on the subject, argued in this manner: If we have two identical machines, one acting as a generator and the other as a motor, the energy required by the former and that given out by the latter is in either case equal to the product of current and electromotive force.

Since the current is the same in both machines, the proportion between the electromotive force in the armature of the generator and the counter electromotive force in the armature of the motor represents also the proportion between the energy expended and recovered. If both machines are identical, the electromotive forces are proportional to the speeds, and hence the ratio of speeds represents the efficiency of the system. Nothing could be more beautifully simple, but at the same time nothing could be so absurd as this statement. Say the two machines are series wound. Then the speed of the motor will be the greater, the smaller the current flowing through it, because a reduction of current results of necessity in a reduction of the intensity of the magnetic field, and that necessitates an increase of speed in order that the counter electromotive force may balance the electromotive force of the generator, proper allowance being, of course, made for the loss of electromotive force occasioned by the resistance of the two machines and the line connecting them. Now assume this line to be leaky. In this case part of the current sent out by the generator does not reach the motor at all, and consequently the field of the motor will be weaker than that of the dynamos. Thus the speed of the motor will be greater than would be the case were the insulation of the line perfect, and the very fault which naturally reduces the efficiency of the system has the effect of making the ratio of the speed higher than it would otherwise be. To determine the efficiency by simply taking the proportions between the speed of the motor and that of the generator is therefore absolutely wrong. But even if the line be perfect, this method is misleading. It will be evident that the ratio of speeds will be the nearer unity, the smaller is the loss of electromotive force occasioned by the resistance of the two machines and of the line, that is, the smaller the current passing. But in this case the total amount of energy transmitted is also very small, and it may well happen that after deducting the energy required to overcome the mechanical and magnetic friction of the motor, nothing is left for useful external work. The actual efficiency of the

1. The *Engineer*.

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whole system would therefore be zero, while the efficiency as estimated from the speeds appears to be a maximum.

The anomalies here set forth are all due to the fact that the commercial efficiency of the machine, whether generator or motor, has not been sufficiently distinguished from the purely electrical efficiency. It is very easy to determine the electrical efficiency of a dynamo. We have only to ascertain what is the electrical energy given out and what is the electrical energy developed in the armature, and to take the ratio between the two. All this is extremely easy, and requires no other apparatus than a Wheatstone bridge to measure the resistance of the different parts of the dynamo, and the usual current and potential indicators. The resistances once ascertained, the other measurements can be taken without in any way interfering with the working of the dynamo; and it is therefore but natural that the makers of these machines often make use of the term "electrical efficiency." But to the practical engineer the term has no meaning. He wants to know how much power he must provide to produce a given electrical output, inclusive of all losses, and he can only ascertain the power beforehand if he knows the actual commercial efficiency of the dynamo he is going to employ.

The usual way of measuring the commercial efficiency of a dynamo machine is by employing some kind of transmission dynamometer placed between the prime mover and the dynamo, and taking simultaneous readings of the energy transmitted and the electrical energy obtained. Now every engineer knows that measurements of that kind are difficult to make, and require costly apparatus, especially if the power to be transmitted is considerable. Only the very best and most expensive forms of transmission dynamometer—such as Tatham's or Brackett's—give fairly accurate results, and a cheaper class of instrument would be perfectly useless, as its own error would probably exceed the difference between electrical and commercial efficiency which we wish to ascertain. It must be remembered that the commercial efficiency of the modern dynamo is far greater than that of any other machine intended to convert energy from one form into another, and that the difference between an excellent dynamo and a fairly good one is reckoned by but a few per cent. in the efficiency. Hence a transmission dynamometer which may have an error of a few per cent. would be useless for our purpose, besides being, on account of its price, beyond the reach of most private individuals.

The difficulties which stood in the way of accurately determining the commercial efficiency of dynamo machines have recently been overcome in a most ingenious manner by a method devised by Dr. John Hopkinson. This method was first described by its inventor in the discussion following the paper on "Modern Continuous Current Dynamo Machines and Their Engines," read by the author in November last at the Institution of Civil Engineers. It consists, broadly speaking, in measuring not the whole of the power supplied to a dynamo, but the power wasted by two similar machines which are mechanically and electrically coupled, the one acting as a generator and the other as a motor. Dr. Hopkinson said: "Supposing 100 to be applied mechanically to the first machine, a power of 90 might be delivered by that machine to the second machine. Of that 90, 80 would in the second machine be converted into mechanical power, which mechanical power would be transmitted by the shaft to drive the first machine. There would remain then to be supplied only 20 for driving the whole combination. The quantities to be measured are then 20 and 90. Suppose that instead of measuring quite accurately, the measurements were 91 and 19.8. That 19.8 waste is divided between two—9.9 for each. Consequently, the first machine, apparently with an expenditure of 100.9, gives 91, so that although errors were made of 1 per cent. in each determination, in the final result of efficiency there is only an error of 0.2 per cent."

A short time ago, the writer had, in company with other engineers, an opportunity of seeing this method put into actual practice at the works of Messrs. Mather & Platt, in Manchester, who were kind enough to allow their visitors to repeat some of the experiments in order that this eminently useful method may be properly understood. The general arrangement of the plant may be thus described. It consisted of two Edison-Hopkinson dynamos, each designed for an output of 320 ampères at a pressure of 105 volts, when driven at 750 revolutions per minute. The shafts were connected by a flexible coupling which at the same time served as driving pulley, receiving motion by a link belt from a steam engine. The power supplied to this pulley could be measured by a transmission dynamometer of the original Hefner-Alteneck type, represented diagrammatically in figure 1, where B is

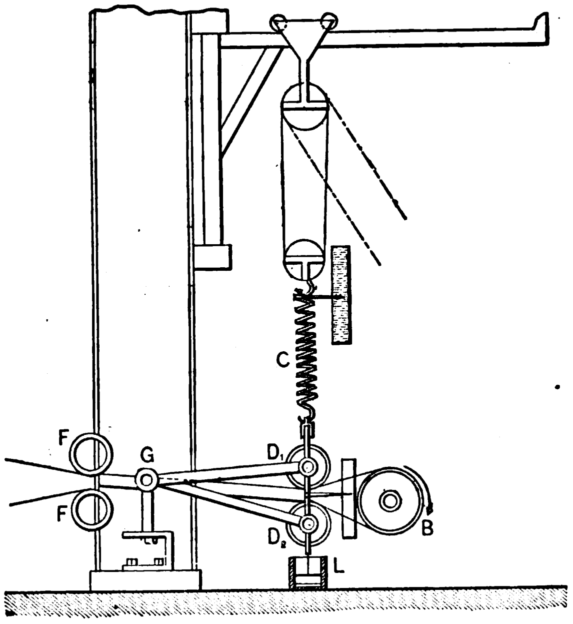

FIGURE 1.

the pulley connecting the shafts of the two dynamos. D_1 D_2 are loose pulleys supported by a frame, which is pivoted at G, and C is an adjustable spring suspended from a crane overhead. The vibration of the frame is reduced by a dash pot, L. The two ends of the belt are taken through guide pulleys, F F, so as to bring them parallel with the dynamometer. If motion takes place in the direction of the arrow, it will be evident that the strain in the lower belt must exceed the strain in the upper belt, and there will be a tendency to displace the frame downward. To counteract this tendency, the top of the spring must be raised until the pointer attached to the frame again returns to a zero mark which had been made while the system was at rest. It is easy to see that in this position the difference in tension between the two sides of the belt must, under all circumstances, be proportional to the increase of tension in the spring, which can be read off by an upper pointer and scale as shown.

The constant of the dynamometer is simply dependent on the geometrical proportions: it is 2.705—that is to say, to each division on the scale corresponds a tangential pull of 2.705 lb. acting at a radius equal to that of the pulley plus half the thickness of belt. To avoid the possibility of error in the geometrical determination of the constant, the latter was verified by combining the transmission dynamometer with an ordinary Prony brake, and comparing the power registered on the dynamometer with the power measured on the brake. One revolution of the pulley represents 3.63 feet advance of belt; hence

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$$\frac{S \times 2.705 \times 3.63\,n}{33{,}000} = \text{h. p.}$$ where s represents the tension of the spring in divisions on the scale, n the number of revolutions of the pulley per minute, and h. p. the horse-power. We have also

$$\text{h. p.} = 0.000298\,n\,S.$$

It will be seen that n and s are the only mechanical data required. The electrical data are the current in the two armatures and the electromotive forces created in the armature coils. We can, of course, only measure the external electromotive forces, and must compute the internal electromotive forces by adding the loss due to the resistances of the armatures. The two dynamos are shunt wound, and their resistances are as follows :

	Ohms.
Armature of generator....................	0.009947
Armature of motor..........................	0.009947
Field magnets of generator..................	16.44
Field magnets of motor.....................	16.93
Resistance of leads, including platinoid coil.	0.00777

The electrical connections will be understood from the diagram, figure 2, where o represents the armature of

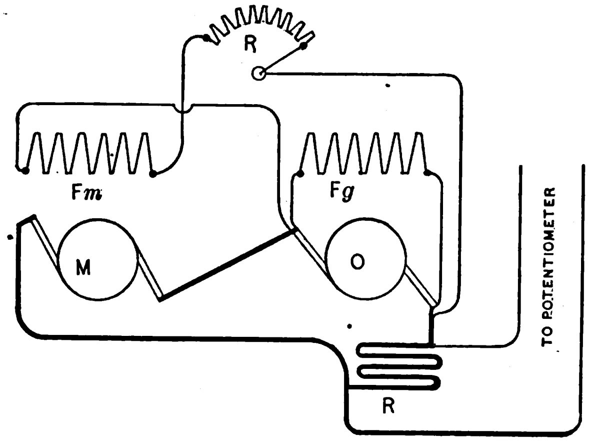

FIGURE 2.

the generator, and M that of the motor, the two being drawn side by side for clearness of illustration, and not in line one behind the other—which is their actual arrangement.

F g represents the field magnet coils of the generator, and F m those of the motor, both being supplied with current from the brushes of the generator. Now, it will easily be seen that if the exciting current were alike in both cases, the counter electromotive force created in M would be equal to the electromotive force created in G, and no current would pass from one armature to the other. To allow a current to flow, it is necessary to slightly lower the counter electromotive force of M, and this is done by reducing the exciting current in F m. The more we reduce the power of this magnet, the more easily will the armature of the motor be overpowered by the armature of the dynamo, and the more current will flow through both armatures, and the circuit shown in thick lines.

In order to regulate the exciting power of the motor field magnets, a rheostat, r, is inserted into the circuit, and by turning the handle of this rheostat one way or the other we can increase or decrease the main current flowing through the system, and therefore the total amount of mechanical energy supplied to the armature of the generator. The main current is measured by observing, on a potentiometer placed in a distant room, the difference of potential existing between the terminals of a platinoid resistance, R. This resistance is so low—0.0058 ohm—that the strongest current which is used during the range of experiments does not sensibly heat it. Moreover, the temperature correction of platinoid is so small that this resistance can be considered to be practically constant.

We, therefore, find the current by dividing the potential at the terminals of R, by 0.0058. The potentiometer is arranged according to Poggendorff's method. Let, in figure 3, A B represent the terminals of the two wires leading from the platinoid resistance R, let C represent a standard cell of known electromotive force—1.453 volts—and let G be a galvanometer connected by a key, D, to a variable resistance, g. The current flows

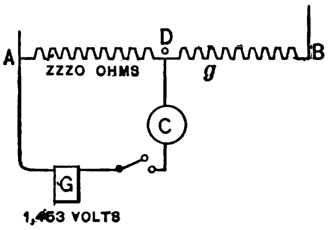

FIGURE 3.

from A through a fixed resistance of 2.220 ohms past the point, D, where the galvanometer is connected, and through the resistance, g, to B.

By suitably varying the latter resistance we can vary the strength of the current, and therefore the difference of potential between A and D. If that difference be exactly 1.453 volts, then no deflection of the galvanometer will be observed upon depressing the key, because the standard cell just balances the electromotive force between A and D. The difference of potential between A and B is, in that case,

$$E = \frac{1.453\ (2{,}220 + g)}{2{,}220}$$

It will be noticed that this method can only be used if $E > 1.453$. For smaller values a similar method is employed, but the standard cell is replaced by a secondary battery of known electromotive force. It would be beyond the scope of this article to enter in detail into the different arrangements necessary. Those who wish for more information will find it in Mr. Kemp's excellent book on "Electrical Testing." The experiments were carried out in the following manner : The two dynamos were first run with the brushes off, neither of the two fields being excited. This gave the power necessary to overcome the friction in the bearings, the resistance of air, and that used up in the dynamometer itself. The next experiment was to excite the two fields separately, and run the dynamos still with the brushes off. This gave the power required to overcome the resistances just specified, plus the energy absorbed by revolving the two armatures in magnetic fields, or, as it might be termed, the power absorbed by magnetic friction. Roughly speaking, the magnetic friction was found to increase the power required for running empty by fifty per cent. The field coils were then coupled up, as shown in figure 2, and the proper power tests were made. In the following table are given some of the results obtained :

DYNAMOMETRIC EXPERIMENTS ON TWO SIMILAR EDISON-HOPKINSON DYNAMOS.

Scale divisions on spring balance..............	21.6	80	60	48.5	44
Revolutions per minute..............	808	802	764	808	808
Electromotive force at brushes of generator....	.....	.....	110.12	118.87	124.41
Electromotive force at brushes of motor.... ..	.....	.....	107.34	116.86	122.97
Electromotive force in armature of generator.	.....	.....	113.79	121.56	126.40
Counter electromotive force in armatureof motor..................	.....	.. ..	108.78	114.29	121.12
Main current in ampères..............	.....	.....	358	258	186
Shunt current in field of generator.........	... .	6.9	6.72	7.21	7.57
Shunt current in field of motor.	.....	6.7	5.23	5.92	6.53
Current in armature of generator..........	.....	.....	370	271	200
Current in armature of motor..........	.....	....	358	258	186
Horse-power registered on dynamometer . ..	5.18	7.17	18.66	11.70	10.60
Horse-power converted in armature of generator..................	.....	.....	56.20	44.00	34.00
Horse-power converted in armature of motor..	.....	.....	49.80	39.60	30.20

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The horse-power converted in the armature of the generator is that actually appearing in the form of internal electrical energy. The power which has to be supplied to the spindle is somewhat greater than the horse-power converted, and the problem is to find how much greater; in other words, we want to find the efficiency of conversion. Similarly, the horse-power converted in the armature of the motor is the electrical energy disappearing in the process of conversion into mechanical energy, which flows through the coupling back into the spindle of the generator. This power is somewhat smaller than that given in the table, because a certain loss occurs during conversion, and we want to find how great this loss is. Since the two machines are similar in size, we shall not commit any great error if we assume that the unknown loss in conversion is the same in both armatures. Let x represent the horse-power thus lost. Then we have the following relation in reference to the experiment given in the third column:

Power supplied from the external source	13.66
Power supplied by the motor	$49.80 - X$

The sum of these two must be equal to $56.20 + X$, which represents the power actually supplied to the spindle of the generator. We have, therefore, the equation:

$$13.66 + 49.80 - X = 56.20 \times X,$$

whence

$$2\,X = 13.66 \times 49.80 - 56.20$$

$$X = 3.63$$

It should here be remarked that in taking 13.66 as the power actually supplied to the whole combination we have made no allowance for the loss occurring in the dynamometer itself. Now, from the first column it appears that 5.18 horse-power are required to overcome the purely mechanical resistance of the dynamometer, the friction of armature spindles in their bearings, and the air resistance of the armatures. The latter two must properly be charged to the dynamos when determining their commercial efficiency, whereas the former should be deducted. It is extremely difficult to separate these losses, and we shall have either to neglect the loss in the dynamometer altogether, which would make the dynamos appear less efficient than they really are, or we must deduct the losses due to the dynamometer and the mechanical friction of the armatures together, which would make the dynamos appear more efficient than they really are. In the latter case the power applied externally would be $13.66 - 5.18 \frac{764}{808} = 8.76$, and the unknown quantity $X = 1.18$.

This value agrees fairly well with the tests in the first and second column, where the increase of power due to the magnetization of the iron core of the armature had been directly ascertained But there is one point which has not been taken into account, and which would slightly modify the efficiency when either of the dynamos was used in actual practical work. This is the increase of mechanical friction in the bearings due to the strain of the belt. It is a very different thing to transmit 10 h. p. through a belt embracing three-fourths of the pulley and to transmit 60 h. p. through a belt embracing, say, only four-tenths of the pulley. The strain in the driving end of the belt will, in the latter case, be probably ten times greater, and therefore the pressure of the spindle against its bearing and the power absorbed by friction will also be considerably increased. In order to make an allowance on this head, probably the fairest thing to do is to take the mean between the two values for x, and in this case we have:

Horse-power in the belt driving the dynamo	58 60
Horse-power delivered electrically at the terminals	53.60

Commercial efficiency, 91.5 per cent.

Similarly we have for the motor:

Horse-power delivered electrically to the terminals	53.60
Horse-power obtainable at the belt	47.40

Commercial efficiency, 88.5 per cent.

In this case the commercial efficiency is somewhat lower for the motor, which is probably due to the fact that the field magnets were not fully excited.

In the same manner we find the average value of x for the figures in the fourth column to be 2.36, and that for the figures in the last column to be 2.10. This gives for the dynamo:

Horse-power in belt driving the dynamo	46.36	and	36.10
Horse-power delivered electrically at the terminals	42.00	"	30.40
Commercial efficiency	90.6%	"	84%

And for the motor:

Horse-power delivered electrically to the terminals	42.00	and	30.40
Horse-power obtainable at the belt	37.24	"	28.10
Commercial efficiency	88.7%	"	92%

The method here adopted by the writer in analyzing the experimental results is somewhat different from that adopted by Messrs. Mather and Platt, but the results arrived at by either method agree fairly well. The commercial efficiency determined according to the makers' way of reckoning, is 93.23 per cent. for the tests recorded in the third column, and the discrepancy of 1.7 per cent. is due to the fact that in the calculation which gives the higher efficiency no allowance was made for the increase of friction in the bearings due to the greater pull of the belt where the latter is transmitting the full power, instead of only that portion of the power which is wanted. These results are very instructive. In the first place they prove that an actual commercial efficiency of 90 per cent. and more can be obtained with a high class dynamo.

They also show that the dynamo, when designed on sound scientific principles, is equally efficient whether used as a generator or motor, a point which has been much discussed of late in the columns of the scientific press. A very important result of the experiments is also that it has been proved to be possible to electrically transmit energy over short distances with a total loss not exceeding 20 per cent.

THE HEATING OF AERIAL CONDUCTORS BY ELECTRIC CURRENTS.

BY J. GILBERT WHITE, PH.D.

INTRODUCTION.

WHILE engaged on some tests for the Franklin Institute at the Electrical Exhibition, in the fall of 1884, the writer found it necessary to consider the effect of heating and consequent change of resistance of aerial conductors carrying electric currents, and was unable to find any data by which the change of temperature due to the passage of a given current, under different conditions of exposure could be determined. It had been noted that, in some cases, covered wires were less heated than naked, by the same current, and Sir W. Thomson had shown by mathematical analysis, that such should be the case for certain values of emissive and conducting powers. But to what extent these conditions obtained in practice, whether covered wires in general kept cooler than naked, or did so only in exceptional cases, had not been determined, and nothing, so far as the writer knew, was known of the relation that existed between the heating of covered and naked wires for any particular case.

It seemed, therefore, desirable that such experiments should be instituted, and in the winter of 1884–5, the writer proposed to Mr. J. G. White, then pursuing a course of graduate study at the Cornell University, to make a thorough study of the subject both theoretically and experimentally. The method adopted for the experimental investigation made it necessary to have continuous wires partly covered and partly naked. These were obtained through the courtesy of the Electrical Supply Co., of New York, who induced manufacturers to prepare for the purpose samples of wire

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in lengths of about one hundred feet, half covered and half uncovered, of a great variety of styles of covering. The investigation proved a much more extended one than was anticipated, and Mr. White, having accepted a position in the University of Nebraska, was obliged to leave it before completing all that had been planned. It is believed, however, that the results so far obtained are of sufficient value to warrant their publication, and it is expected that the investigation will be continued.

PHYSICAL LABORATORY,
Cornell University,
Ithaca, N. Y., May 10, 1886.
WM. A. ANTHONY.

THE heating of conductors by electric currents is a subject of great practical as well as theoretical interest. It constitutes a leading factor in many of the electrical engineering problems of the day, especially in those of electric lighting and transmission of power. All electricians are familiar with the heating of wires by currents, and know that overheating is not economical, injures the insulation, and may even lead to firing of buildings or ordinary combustibles.

Yet very little has been written in this country on the subject; and, so far as we can learn, no experiments have been made. Letters from several of the leading electricians of the country show that quite diverse opinions are held on the most important and practical problems connected with the subject. Furthermore, many of the practical electrical engineers compute the size of wire to be used for any purpose by the rule (prescribed by the Board of Underwriters) of allowing a certain number of ampères current per square inch cross section of the conductor. This rule, as we shall show later, is proven to be wrong by theory and by experiment, and might lead to serious consequences if the computations were for large currents.

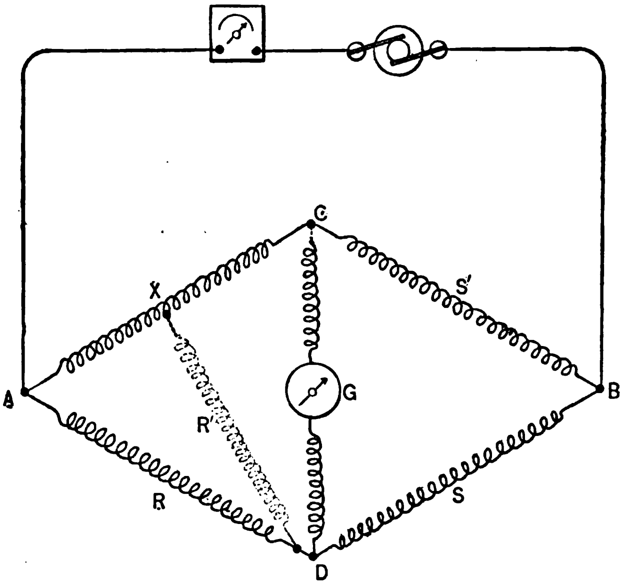
In Europe a number of articles have appeared in the scientific periodicals which have discussed the various questions connected with electric conductors; but the results arrived at have been quite unlike, and very few have gone into any experimental verification of their theoretical deductions. It has, therefore, seemed wise to undertake some experiments which might verify the results of the theoretical solutions which might be found in other articles or which might be deduced. A description of the method of conducting the experiments and a synopsis of the results will now be given in order that these results may be referred to from the theoretical discussions given later in this paper; and the results reached by the two methods compared.

The currents used in the experiments were obtained from a Gramme generator, independently excited by a small Weston generator. By having a proper set of resistance coils in the 'field' of the Weston machine and also between the Weston and the 'field' of the Gramme machine, the amount of the current could be varied at will. The temperature of the wire experimented upon was determined by its resistance, which was measured by means of a Wheatstone bridge.

An idea of the connections may be obtained from an inspection of the following figure.

x consists of the wire under consideration. When two wires were to be compared they were joined and the current sent through them in series. By means of a temporarily devised mercury key the connections could be made so as to give R the position shown full or dotted. By determining R and R′ alternately, we get values for the resistance of one wire and of both. By subtracting the average value of R′ from the average value of R, the value of the resistance of the other wire could be obtained. R and R′ were readings on one of Elliott Brothers' four dial resistance boxes; and since they were always thousands of ohms, any slight difference in the resistance of the connecting wires in the two positions, would be entirely inappreciable. *s* was a length of No. 00 insulated wire very loosely coiled so as to be well ventilated. *x* was in most of the experiments a No. 16, No. 18, or No. 20 wire, and hence *s* being so much larger than *x* in diameter would not be appreciably heated by the currents which were used to heat *x*.

At all events, all the experiments of practical significance consisted in the comparisons of two wires; and, since any slight alteration of *s* would make the same percentage of difference in R and R′, such a change would not vitiate the results. A little study of the experiments in the results of which this slight change in *s* would introduce *any* error, shows that, at most, this error would be only a fraction of one per cent. Owing to the variable factors which enter into these results, this is considered as within the limits of attainable accuracy for these particular experiments. *s* was a part of the resistance of an



ordinary resistance box, and remained constant during any set of experiments; but was varied when a new wire was placed at *x* so as to have R as large as possible in all instances. Connections were so made that by keys on the resistance box containing R the circuit A R D S B could be closed, and, immediately afterward, the galvanometer circuit. As *x* and *s* were only fractions of an ohm, and as (R + S) was always thousands of ohms, the current which flowed through R and S for the short time during which the circuit A R D S B was closed, was very small; and R and S were not appreciably heated. G was a delicate galvanometer.

The above description shows that the bridge was so arranged that the results obtained from its readings can be relied on. In each of the experiments the resistance of the wire *x* was obtained, when the wire was cold, by means of one or two gravity cells. Then as only *x* and R changed during the experiment, the increase in R would enable the per cent. of increase in *x* to be computed. The temperature of *x* was then computed, on the assumption that the resistance of *x* increased 0.388 per cent. for each rise of one degree centigrade. This assumption is not exact; since $R' = R(1 + at + bt^2)$, in which equation R′ is the resistance at any temperature *t*, R the resistance at zero, and *a* and *b* are constants determined experimentally. Now *b* is so small in comparison with *a*, that it is only when *t* becomes of considerable magnitude, that the second term becomes worthy of attention. The calculations have therefore been made as indicated above.

To determine the current flowing at any time one of Thompson's ammeters with sliding magnet and needle was connected in the main circuit. The constant of this instrument was determined by means of the copper voltameter, and found to be 5.2608, or with instrument set

at 32	current	=	.1644 ×	deflection
" 16	"	=	.3288 ×	"
" 8	"	=	.6576 ×	"
" 4	"	=	1.3152 ×	"

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Other determinations by other persons, during the progress of the experiments given below, gave almost exactly the same result. The experiments are given below not in the order in which they were made; but in what seems to be the logical sequence.

EXPERIMENTS, SET 1.

To determine the law of variation of the temperature of a conductor after starting through it a current of constant intensity. To determine this law the main circuit was so arranged that it could be closed by means of a mercury key at any instant. Several of the students in the laboratory kindly assisted in this experiment; so that the following arrangement could be made. One person observed and took frequent readings on the ammeter, to see that the current remained steady. Another closed the circuit at the beginning of a minute; at the expiration of each half minute thereafter he called out a signal, having given a warning signal five seconds before.

The writer was stationed at the 'bridge,' and maintained, by changing R, as nearly as possible a balance, calling out the reading of R to another person at the end of each half minute. Of course the exact values of R at the precise instant could not be determined, owing to its constantly changing magnitude; but fairly accurate results were obtained as is shown by the smoothness of the curves on the cross-section paper. In laying out these curves, the rise in temperature of x in degrees calculated as explained above, was taken as an ordinate, the number of half minutes since the closing of the circuit being taken as the corresponding abscissæ. The results of the experiments are tabulated below, and the curves plotted on cross-section paper, plate I. Experiments 1, 2, 3, 4 were made with Clark insulated wire; 5 and 6 with bare wire of same size, 0.038 inch in diameter.

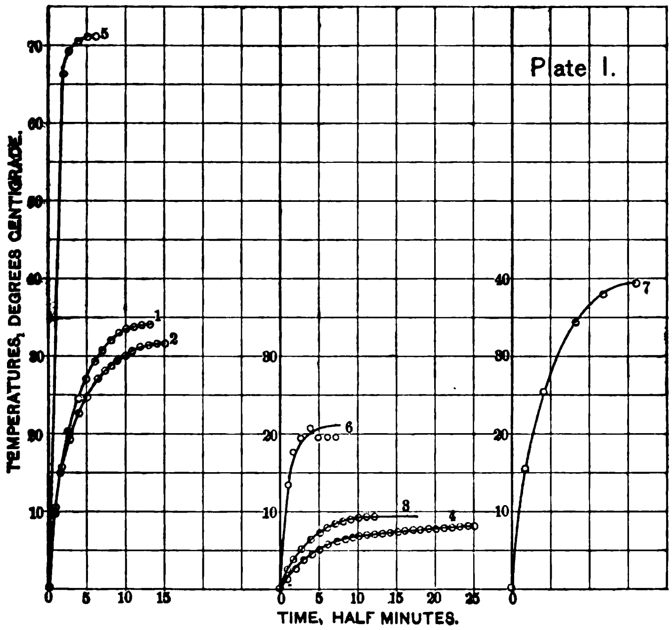

TABLE I.—EXPERIMENT 1.—SET 1.

Time in half minutes.	Values of R.	Increase in values of R.	Rise in temp of x.
0	3735	....	....
1	3880	145	9.66
2	3960	225	15.00
3	4030	295	19.66
4	4070	335	22.33
5	4107	372	24.80
6	4135	400	26.26
7	4160	425	28.33
8	4173	438	29.20
9	4182	447	29.86
10	4190	455	30.33
11	4196	461	30.73
12	4200	465	31.00
13	4202	467	31.13
14	4203	468	31.20

TABLE II.—EXPERIMENT 2.—SET 1.

Time in half minutes.	Values of R.	Increase in values of R.	Rise in temp. of x.
0	3757	...	....
1	3910	153	10.20
2	3990	233	15.41
3	4060	303	20.20
4	4115	358	23.86
5	4155	398	26.13
6	4180	433	28.86
7	4205	458	30.06
8	4223	476	31.26
9	4240	493	32.86
10	4250	503	33.53
11	4255	508	33.86
12	4258	511	34.06
13	4258	511	34.06
14	4255	508	33.86

TABLE III.—EXPERIMENT 3.—SET 1.

Time in half minutes.	Values of R.	Increase in values of R.	Rise in temp. of x.
0	3746	....	0.0
1	3785	39	2.60
2	3810	64	4.26
3	3827	81	5.40
4	3842	96	6.40
5	3854	108	7.20
6	3862	118	7.86
7	3868	124	8.20
8	3872	128	8.46
9	3878	134	8.93
10	3880	136	9.06
11	3882	138	9.20
12	3883	139	9.26

TABLE IV.—EXPERIMENT 4.—SET 1.

Time in half minutes.	Values of R.	Increase in values of R.	Rise in temp. of x.
0	3735	....	....
1	3762	27	1.80
2	3782	47	3.13
3	3795	60	4.00
4	3806	71	4.70
5	3815	80	5.33
6	3821	86	5.73
7	3826	91	6.07
8	3832	97	6.44
9	3836	101	6.70
10	3839	104	6.93
11	3841	106	7.07
12	3843	108	7.20
13	3844	109	7.27
14	3845	110	7.33
15	3847	112	7.48
16	3848	113	7.54
17	3849	114	7.60
18	3851	116	7.73
19	3852	117	7.80
20	3853	118	7.86
21	3854	119	7.93
22	3855	120	8.00
23	3854	119	7.93
24	3853	118	7.86
25	3854	119	7.93

TABLE V.—EXPERIMENT 5.—SET 1.

Time in half minutes.	Values of R.	Increase in values of R.	Rise in temp. of x.
0	3377	...	....
1	....	...	....
2	4370	993	66.20
3	4420	1043	69.53
4	4440	1063	70.87
5	4465	1068	71.20
6	4465	1068	71.20

TABLE VI.—EXPERIMENT 6.—SET 1.

Time in half minutes.	Values of R.	Increase in values of R.	Rise in temp. of x.
0	3377	...	.....
1	3580	203	13.53
2	3650	273	18.20
3	3675	298	19.86
4	3678	301	20.67
5	3671	294	19.73
6	3674	297	19.80
7	3674	297	19.80

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The next set of experiments had for its object the determination of the law of the relations of different currents, and the temperatures which they were able to maintain.

After the current is started in a wire, the emission of heat will increase with the temperature of the wire, until the heat given off just equals the heat developed, when the temperature of the conductor will remain constant. But each current will have its own permanent temperature for any wire under given conditions. To determine the law of this variation, a current was started and allowed to run fifteen or twenty minutes before any observations were taken. Then observations were taken as in the following sample set, the readings of each horizontal line being taken before any of those in the next lower line.

TABLE VII.

R. for bare wire.	R.	R′. for bare + insulated wire.	R′.	Thompson Ammeter. Right.	Thompson Ammeter. Left.
4020	4020	8006	8007	0.0	0.0
4195	4198	8338	8343	38.8	41.0
4195	4193	8345	8343	41.0	41.8
4195	4195	8338	8340	40.0	39.3
4193	4190	8330	8330	38.0	38.6
4193	4195	8333	8335	38.8	38.6
Mean of R. 4194		Mean of R′. 8338		39.63	

In the following tables all the experimental data were found by taking the average of a number of determinations similar to the above, and the calculations were made from these averages.

The curves on the cross-section paper, plate II., were laid out by taking the rise in temperature of the wire in degrees Centigrade as ordinates, and the currents in ampères as abscissæ.

Experiments 1, 2, 3, 4, 5, 6, were made with No. 16 wire, all of the same piece, the bare part having been stripped of its insulation, which was a double layer of paraffined cotton. Nos. 1, 2, 3 and 4 were conducted with the two parts of the wire suspended side by side in a closed room, about 50 feet of each kind being used.

In 5, 6, 7 and 8 the wires were arranged in a similar manner in the open air, the remainder of the apparatus being inside the laboratory.

TABLE VIII.—EXPERIMENT 1.—SET 2.

Resistance of bare wire.	Resistance of both.	Resistance of insul.	% of increase, resist of bare.	Rise in temp. of bare.	% of increase, resist. of ins.	Rise in temp. of ins.	Current in ampères.
4019	7980	3961	0.0	0.0	0.0	0.0	....
4194	8337	4143	4.35	11.5	4.62	12.2	4.62
4279	8470	4190	6.48	17.0	5.72	15.0	8.30
4295	8477	4181	6.56	17.5	5.64	14.6	8.67
4442	8695	4257	10.42	27.4	7.47	19.6	12.17
4598	8938	4340	14.40	37.8	9.57	25.2	16.63
4754	9203	4448	18.31	48.2	12.26	32.3	18.58
5075	9668	4593	26.02	68.4	15.94	41.9	22.00
5018	9582	4569	24.73	65.1	15.09	39.7	22.10
5282	9972	4690	31.42	82.7	18.14	47.1	25.19
5624	10545	4898	40.50	106.6	23.15	60.9	29.29

The observations of the above table were not all taken the same day, so there is some irregularity, owing in part, at least, to changing atmospheric conditions.

TABLE IX.—EXPERIMENT 2.—SET 2.

Resistance of bare wire.	Resistance of both.	Resistance of insul.	% increase, resist. bare.	Increase in temp. of bare.	% increase, resist. of ins.	Increase in temp. insul.	Current in ampères.
4240	8405	4165	....	....	....	....	....
4263	8445	4182	0.54	1.4	0.41	1.1	3.29
4330	8539	4209	2.12	5.4	1.05	2.9	6.66
4429	8691	4262	4.46	11.4	2.09	5.3	10.03
4685	9080	4395	10.73	27.5	5.52	14.2	15.85
4966	9508	4542	17.01	43.6	9.05	23.2	19.73
5330	10022	4692	25.71	65.9	12.65	32.4	23.25
5737	10643	4906	35.30	90.5	17.55	45.5	28.09

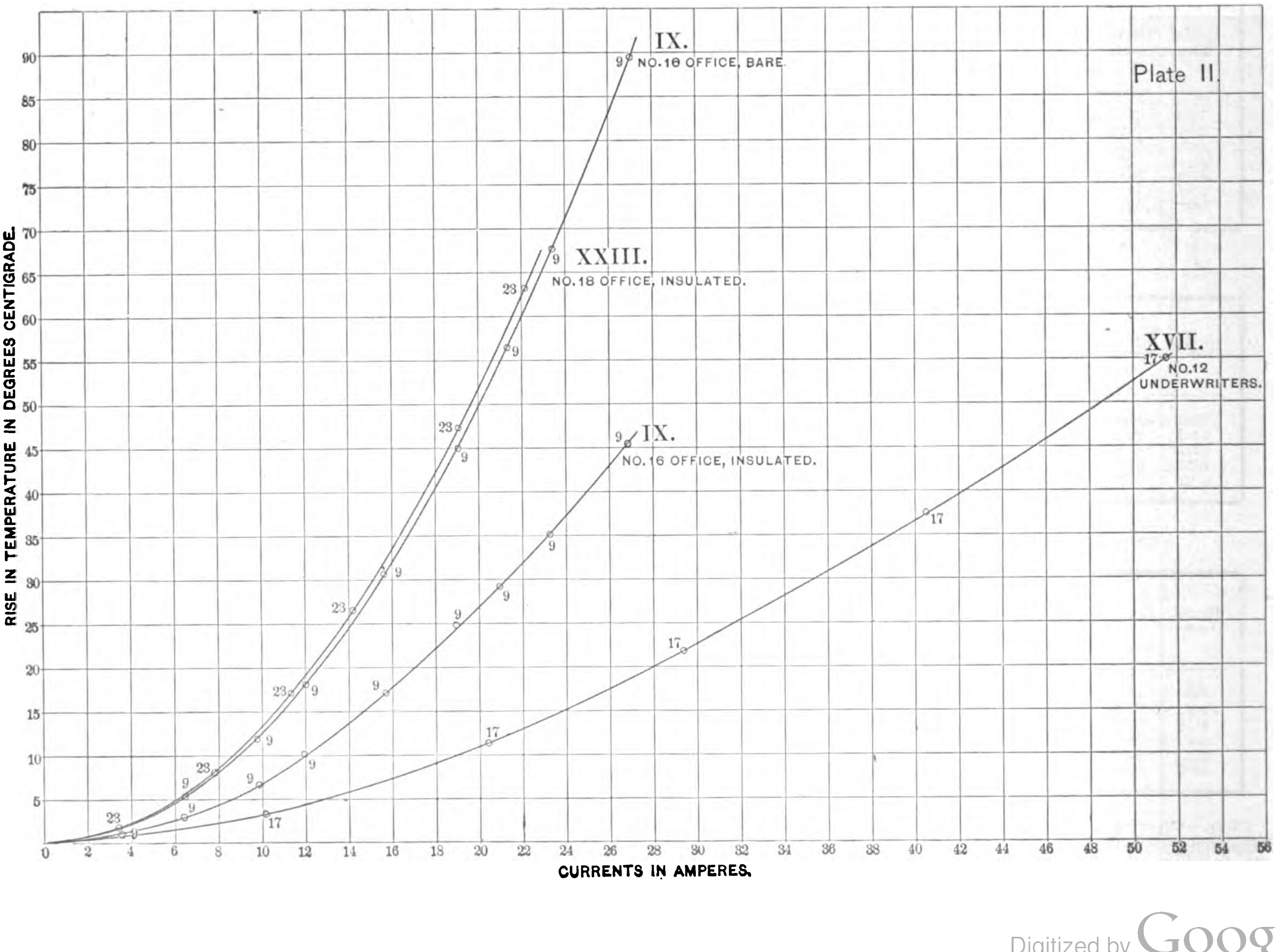

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TABLE X.—EXPERIMENT 3.—SET 2.

Resistance bare.	Resistance both.	Resistance insul.	% increase, resist. bare.	Increase in temp. of bare.	% increase, resist. insul.	Increase in temp. insul.	Current in ampères.
4210	...	4142	....	....	...	....	....
4227	8382	4155	0.41	1.1	0.38	1.0	3.62
4301	8492	4191	2.16	5.7	1.18	3.0	7.04
4389	8634	4245	4.23	11.1	2.48	6.5	9.73
4534	8857	4323	7.69	19.7	4.13	10.6	13.38
4725	9121	4396	12.23	31.3	6.13	15.7	17.03

TABLE XI.—EXPERIMENT 4.—SET 2.

Resist. bare.	Resist. both.	Resist. insul.	% increase, resist. bare.	Rise in temp. bare.	% increase, resist. insul.	Rise in temp. insul.	Current in ampères.
4180	....	4172	....	....	....	....	....
4201	8390	4189	0.58	1.4	0.41	1.1	3.22
4309	8546	4237	2.14	5.5	1.15	2.9	6.64
4390	8666	4276	4.52	11.6	2.48	6.5	9.63
4500	8854	4354	7.64	18.3	4.26	10.9	11.84
4717	9144	4427	12.07	30.9	6.01	15.3	15.65
4946	9512	4566	17.52	44.9	9.42	24.5	19.00
5127	9778	4649	21.95	56.3	11.40	28.5	21.00
5323	10088	4760	25.86	67.2	14.04	35.1	23.48
5787	10719	4932	35.40	89.0	18.18	45.5	26.88

TABLE XII.—EXPERIMENT 5.—SET 2.

Resist. insul.	Resist. both.	Resist. bare.	% increase, resist. bare.	Rise in temp. bare.	% increase, resist. insul.	Rise in temp. insul.	Current in ampères.
3833	7750	3917	....	....	....	....	....
3846	7783	3937	0.51	1.3	0.34	0.9	4.01
3890	7900	4010	2.37	6.1	1.53	3.9	12.36
3973	8167	4194	7.72	19.8	3.66	9.4	17.18
4260	8776	4507	15.06	38.6	8.57	22.0	27.62

TABLE XIII.—EXPERIMENT 6.—SET 2.

Resist. bare.	Resist. both.	Resist. insul.	% increase, resist. bare.	Rise in temp. bare.	% increase, resist. insul.	Rise in temp. insul.	Current in ampères.
3880	7683	3803	...	....	...	....	....
3901	7736	3835	0.54	1.4	0.88	2.3	3.31
3949	7831	3882	1.77	4.3	2.07	5.3	6.80
4011	7928	3917	3.37	8.6	3.00	7.7	11.64
4029	7963	3934	3.84	9.8	3.45	8.8	14.90
4207	8276	4069	8.42	21.6	6.00	15.4	19.50
5907	10932	5025	53.26	136.6	32.15	82.4	40.83

TABLE XIV.—EXPERIMENT 7.—SET 2.

Resist. bare.	Resist. both.	Resist. of insul.	% increase, resist. bare.	Rise in temp. bare.	% increase, resist, insul.	Rise in temp. insul.	Current in ampères.
3940	8020	3980	....	..	...	....	....
4222	8285	4063	7.15	18.3	2.09	5.3	16.07
4397	8600	4203	11.34	29.1	5.60	14.3	21.81
4655	9026	4371	17.88	45.8	9.82	25.1	26.90
5122	9730	4608	30.00	76.9	15.78	40.5	33.97

TABLE XV.—EXPERIMENT 8.—SET 2.

Resist. bare.	Resist. both.	Resist. insul.	% increase, resist. bare.	Rise in temp. bare.	% increase, resist. insul.	Rise in temp. insul.	Current in ampères.
3950	7890	3940	....	....	....	...	....
4032	8020	3988	2.08	5.3	1.22	3.13	7.96
4118	8174	4056	4.25	10.9	2.94	7.5	13.68
4265	8376	4111	7.97	20.4	4.34	11.1	21.05
4355	8560	4205	10.25	26.3	6.73	17.0	26.93
4902	9330	4448	24.40	62.6	12.89	33.1	34.52

(*Note.*—Experiment 5 of the above set was made during a driving snow-storm, hence the increase in temperature for a given current is less than in any other experiment.)

The following experiments in this set (Nos. 9, 10, 11 and 12) were made with a piece of No. 12 "underwriter's wire" alone for x.

TABLE XVI.—EXPERIMENT 9.—SET 2.

Resist. R.	% increase resist. x.	Rise in temp.	Current in ampères.
2174	0.0	....	...
2187	0.60	1 5	8.15
2214	1.84	4.7	16.17
2264	4.14	10.6	24.16
2330	7.13	18.3	35.13
2398	10.30	26.4	38.68
2560	17.76	45.5	51.95

TABLE XVII.—EXPERIMENT 10.—SET 2.

Resist. R.	% increase resist.	Rise in temp.	Current in ampères.
2152	....	....	....
2180	1.3[illegible]	3.3	10.09
2248	4.56	11.7	20.78
2332	8.46	21.9	29.33
2475	15.72	37.7	40.77
2610	21.40	54.9	51.62

TABLE XVIII.—EXPERIMENT 11.—SET 2.

Resist. R.	% increase resist.	Rise in temp.	Current in ampères.
2146	....	....	....
2164	0.84	2.2	8.22
2214	3.16	8.1	18.41
2307	7.48	19.2	27.22
2461	14.65	37.5	39.89
2683	24.79	63.5	52.69

TABLE XIX.—EXPERIMENT 12.—SET 2.

Resist. R.	% increase resist.	Rise in temp.	Current in ampères.
2150	....	....	....
2181	1.44	3.7	12.55
2555	18.84	48.3	46.47
2726	26.79	68.7	54.91

TABLE XX.—EXPERIMENT 13.—SET 2.

Resist. R.	% increase resist.	Rise in temp.	Current in ampères.
6113	...	....	....
6165	0.85	2.2	3.14
6405	4 76	12.2	9.43
7265	18.85	48.3	19.50

TABLE XXI.—EXPERIMENT 14.—SET 2.

Resist. R.	% increase resist.	Rise in temp.	Current in ampères.
6150	....	....	...
6192	0.68	1.7	3.24
6271	1.95	5.0	6.52
6468	5.17	13.3	10.58
6650	8.11	20.8	13.68
6942	12.88	33.0	16.83
7443	21.02	53.9	21.10

TABLE XXII.—EXPERIMENT 15.—SET 2.

Resist. R.	% increase resist.	Rise in temp.	Current in ampères.
6075	0.0	0.0	0.0
6236	2.72	7.0	7.47
6754	11.22	28.8	15.19
7439	23.59	60.5	21.37
6115	0.0	0.0	0.0

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TABLE XXIII.—EXPERIMENT 16.—SET 2.

Resist. R.	% increase resist.	Rise in temp.	Current in ampères.
6100	....	...	....
6138	0.63	1.6	3.26
6281	2.96	7.6	7.76
6502	6.59	16.6	11.27
6721	10.34	26.5	14.14
7205	18.11	46.4	19.29
7602	24.62	68.1	22.10

In the above set of experiments, Nos. 13, 14, 15, and 16 were made with No. 18 paraffined office wire, cotton wrapped.

The next set of experiments had for its object the determination of the relation of the diameter of a wire to the temperature at which a current could maintain it. To accomplish this with accuracy it is essential that the changing atmospheric conditions should not introduce a variable factor into the results. To avoid this one wire was taken as a standard, with which all the others were compared. By arranging the two wires as previously described they could be compared under exactly similar surroundings; and the standard wire in each set of experiments would show any change in atmospheric conditions and permit of corrections being made.

The diameters of the wires were determined by measuring with a micrometer screw gauge reading to ten thousandths of an inch. Each diameter was measured ten times in different parts of the wire, and the average of these ten readings is the one given in the tables. R, R′, and the Thompson ammeter were each read fifty times, and values in the tables are in every case the average of fifty observations. By laying off the diameter in mils as abscissas and the temperatures as ordinates, we get a curve representing the desired relations.

Another set of experiments had for its object the determination of the effect of an insulating covering upon the temperature which a current would maintain. In order to have as few inaccuracies as possible, Professor Anthony obtained, through the courtesy of the manufacturers, wire in lengths of about 100 feet, of which half of each size was covered with their ordinary insulating material, the other half being left bare. The dimensions given are the average of ten readings on the micrometer screw gauge reading to tenths of a mil, and the values of R, R′, and the reading of the ammeter are the averages of thirty observations. Deductions from the results are made later, after the theoretical discussion of this problem has been given.

Having given the data of experiments and the results derived therefrom, it now remains to compare these results with those obtained from theoretical considerations or by other experimenters. From the definitions of the C. G. S. system of electrical units, one volt-ampère or watt $= 10^7$ ergs $= \frac{1}{9.81}$ kilogrammetres. But C E $= C^2$ R; hence the work done by a current, C, in passing through a resistance, R (C in ampères and R in ohms), $= C^2 R$ watts $= \frac{C^2R}{9.81}$ kilogrammetres per second. Since this energy is all converted into heat, we have the heat developed in a conductor $= \frac{C^2R}{9.81}$ kilogrammetres $= \frac{C^2 R}{9.81 \times .424}$ calories, since one calorie (lesser) equal .424 kilogrammetres.

(*To be continued.*)

KEEP UP WITH THE PROCESSION.

In every branch of trade styles are constantly changing and improvements making, and the craftsman who is not prepared to meet and study them as they arise will very speedily find himself in the rear—"left." What is termed "learning a trade" is merely a course of study that teaches one how to learn, just as a knowledge of the alphabet is a key to all knowledge.

RESEARCHES UPON THE SELF-INDUCTION OF AN ELECTRIC CURRENT.

BY PROFESSOR D. E. HUGHES, F. R. S.

(Concluded from page 265.)

INFLUENCE OF CIRCULAR MAGNETISM.

I HAVE shown in my late paper that an iron conductor composed of numerous fine stranded wires (as in a rope) behaves like copper, and this I regard as entirely due to the breaking up or prevention of circular magnetism; I also showed a phenomenon which I could not then explain, viz., that when an iron wire was heated to a yellow-red heat it lost its previous high specific inductive capacity and behaved like copper. The effect of heat upon magnetism is well known; consequently, we can readily explain the fall in its inductive capacity by the disappearance of its circular magnetism. I found also that in thin flat strips of iron there was no change whatever in its inductive capacity at the yellow-red heat; this can now be readily explained: it behaved like copper when cold, and, having but little circular magnetism to destroy, there was no appreciable change produced, except that due to the extra resistance caused by the increased temperature of the strip, and to which copper and iron are almost equally sensitive, consequently we may consider iron (when in the form of thin flat sheets) to behave like non-magnetic metals throughout all temperatures.

INFLUENCE OF SELF-INDUCTION ON THE RESISTANCE OF THE CONDUCTOR.

A phenomenon of great importance is the effect which I have observed of the resistance of a wire being greater during the rise of the current, as in the variable period, than that measured or known during the constant flow, as in the stable period; by resistance I mean a pure ohmic resistance, a resistance which can only be measured, expressed, or balanced in ohms, and, whatever the cause, the effect is one of pure ohmic resistance.

We can imagine that at the first moment of contact there is no current flowing through the wire, its resistance is then infinite, but the current gradually increases in force until it arrives at its maximum, as in the stable period. We have thus between the moment of contact and period of steady flow a variable period wherein the resistance falls in the form of a curve from infinity to its well-known stable resistance; the telephone is unable to give the exact form of this curve directly, but it gives by the method comparative results as to the different duration in time of the curve in different metals.

If we take a straight copper wire 1 metre in length and balance its resistance in the stable period, we shall find that there are only traces of a difference in its resistance in the variable period, and we can balance its self-induction by the induction balance; but if we replace the copper by an iron wire of the same length, or even a much shorter wire, viz., 20 cm., we find that in the variable period we can no longer balance the wire by the induction balance alone, but we must compensate for its increased resistance by the sliding scale, the amount of subtracted german-silver wire expressing in fractions of ohms (the value of the wire being already known) the additional resistance of the iron wire in the variable period; we can thus reduce or balance the iron wire to a perfect zero, provided the current from the battery does not exceed 0.10 ampère; but with greater current there will still remain a slight muffled sound, which cannot be reduced to zero either by the induction balance or the resistance slide. It therefore became important to determine if this muffled sound was due to a difference in resistance which could not be balanced, or to the lengthened duration of the extra currents being slower than the balancing current from the induction balance; the latter proved to be the case, for on prolonging the duration of the balancing currents from the induction bridge by introducing a core of iron in its coil, the balance or zero became

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absolutely perfect. In this case we must choose between cores of different diameter to find one whose reaction on the time effect of the induction coil equals the retardation of the extra currents in the wire tested.

If we observe the method employed in the bridge, we shall see that the induction balance can balance the extra current of the wire X, irrespective of the position of the resistance slide M, or any relation between the sides AB and AD, but we cannot equalize the resistance of these sides except by the necessary adjustment of the resistance slide; consequently, when we are forced to adjust the induction balance we are compensating the extra current, and when we are forced to move the resistance slide we are balancing resistance.

The disturbance in the bridge caused by the change of resistance of the wire tested in the variable period, causes a momentary primary current to pass through the telephone in the same direction as the extra current, and if these are not separated by balancing the extra current by an induction balance, the mixed effect would be read as a single effect of the extra current. To show the importance of separating these two effects, it is only necessary to say that in most of the cases cited in this paper the momentary primary current due to the extra resistance greatly exceeds that of the extra current; consequently, all measurements taken wherein this separation is not complete, give the result of a mixed effect.

In the method which I have described, the separation of the extra current from the momentary primary current is so complete that the measures given by the induction balance and resistance slide are invariably the same for a given wire; there is no personal equation, for all observers find precisely the same values both for the resistance and for the extra current.

The method is, however, defective in measuring any small difference of resistance in the variable period in copper wires, as the induction balance itself introduces an additional but opposing resistance by the approaching of its coils, consequently any resistance which we observe is a fraction less than the real amount. To prove this we have only to use a balancing induction current produced from the battery circuit, as shown in my first paper, when we observe this small difference, and better, observe any small difference of resistance in a straight copper wire, and greater when the wire is formed into a coil.

Soft iron wire gives a far higher resistance in the variable period than hard iron, but each wire, according to its molecular structure, has its own value; the effect increases with the diameter, ranging from 25 per cent. increase of resistance for wires of 2 mm. in diameter, to 500 per cent. for those of 6 cm.

TABLE II.
Resistance of iron and copper in the stable and variable periods.

Wires, 1 m. in length, 5 mm. in diameter.	Comparative force of the extra current.	Resistance in ohms, stable period.	Resistance in ohms, variable period.	Percentage of increased resistance in variable period.
Copper	78	0.001284	0.001372	7
Soft Swedish iron	234	0.008346	0.022200	166
American compound wire, copper exterior, steel interior	83	0.002247	0 002696	20
Ditto, steel exterior, copper interior	218	0.007750	0.0248000	220

Table II shows a few illustrative examples: the resistance is given in the fractions of the ohm, indicated by the resistance slide M, upon the supplementary resistance wire H I.

The table shows that copper and the American compound wire coated with copper have an extremely rapid action or curve from an infinite to a stable resistance, due to their freedom from circular magnetism, whilst iron shows a comparatively slow curve. A remarkable result will be seen where a copper wire has been coated with steel, its variable resistance being 220 per cent. above that of its stable period, and 54 per cent. greater than that of a solid iron wire.

I found in my previous researches that the resistance in the variable period could not be changed by a change in speed of a periodic or tuning-fork contact maker, and that the telephone was more sensitive when the rubbing contacts were used without any regard to their frequency of interval. I also found that the telephone was far more sensitive and only suitable for these experiments when its diaphragm was entirely free from varnish or coating, and sufficiently thick to give a clear musical dominant tone of about C or 512 double vibrations per second, the electro-magnet being also as close as possible without being in actual contact. I noticed that no matter what number of vibrations were sent, that the tones given by the telephone on each side of the zero of the bridge were invariably those of its dominant note. Suspecting that the frequency of vibration of the diaphragm had a direct relation with the resistance found, I altered its note through a range of one octave by employing different thickness of diaphragms, and found that the results were in absolute proportion to the frequency of the vibrations of the diaphragm. The highest tone giving a perfect zero with a high resistance in the variable period and the low tone giving its zero at a marked less resistance. Thus it was evident that the telephone selected from the mixed vibrations sent by the transmitter those which alone corresponded to its period of vibration, and that we could thus observe the effect of more or less rapid periodic contacts.

The power which vibrating bodies have of selecting from a confused number of vibrations those in accordance with their own, is shown in Helmholtz's resonators, and still more as regards electrical waves in the remarkable harmonic telegraph of Elisha Gray, who proved that if the armatures of several electro-magnets are made to vibrate, each with a different musical tone or rate of vibration, then we may by the use of a vibrating transmitter of a fixed rate of speed select the electro-magnet alone whose period of vibration is similar, and that we may send several different periods of vibration at the same time without any confusion in the receiving magnets, as each electro-magnet selects from the compound vibrations those in accordance with its own. This is exactly what occurs with a telephone when using a periodic contact maker, but I have found in addition, that a telephone arranged as I have described, will select and respond loudly in its own clear musical dominant tone to a confused mass of rapid contacts such as those produced by a scraping contact, and which in an ordinary telephone gives only the effect of noise, of not one-third the power or loudness of that produced by the tone of the musical telephone. We may thus have ten or more telephones of different musical notes, each responding separately in its own tone or all at the same time, as each diaphragm selects its own period from the confused periods of contacts sent by the scraping contact maker.

In order to verify the results, I have used in these experiments both periodic and mixed sound transmitters, but find that owing to the difficulty of keeping the periodic transmitter and telephone in perfect tune with each other, that the mixed sound transmitter is preferable, as it gives no trouble whatever, and we have more accurate results, as we then have only to keep our telephones in accord with the number of vibrations desired.

The experiments mentioned in this paper were all made with a fixed note of vibration of the diaphragm of 512 double vibrations per second. I will, however, mention a few made with varying rates of vibration, and as I propose in a future paper to give a more extended series of observations through a wider range, I will confine myself to these examples.

The diagram shows the results obtained on iron wires of different diameters; their stable and variable resistance

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were all reduced to comparative values, the stable resistance being taken as 100. Three telephones were employed, the first having the musical note of G or 768 double vibrations, the second C sharp or 576 double vibrations, and the third, one octave below the first or G, 384 double vibrations per second.

It will be seen that a great change in the variable resistance takes place in the range of a simple octave, and that the fall from the wires of 6 mm. to that of 1 mm. is so regular as to be almost a continuous curve, and the total curve would be probably that taken by the wire of 6 mm. in its approach to its stable resistance. If this is the case, as future researches may show, then the resistance of this wire with the comparatively slow contact speed of six per second would still have 14 per cent. higher resistance in the variable than in the stable period, or an ordinary Morse telegraph instrument working at a slow speed of only eleven words per minute would experience this additional resistance ; consequently, this effect should be easy to prove by the ordinary methods with galvanometers, and this can be accomplished as soon as we have found a method of completely separating the extra current from that due to the increased resistance, as I have already succeeded in doing by the method which I have described.

The iron wire of 6 mm. diameter shows for a speed of 384 contacts per second a comparative resistance in the variable period of 638, or more than six times its stable resistance, but with 192 contacts per second its resistance is but 371 ; the fall of resistance is so rapid here that for a single octave difference in the telephones, the fall is far greater than the whole stable resistance. The extra current, as well known, is proportional to the length of contact for fine wires, but in large wires the curve indicates that the extra currents have a local reaction on the cessation of the primary current.

INFLUENCE OF A MAGNETIC SHEATH.

The remarkable phenomenon wherein a non-magnetic metal such as copper shows a higher " variable " resistance when under the influence of an external coating of iron than a wire of solid iron (and this notwithstanding that the resistance of the side of the bridge is kept a constant, or by balancing its resistance on the opposite side GD as mentioned) seemed worthy of experimental research.

Experiments were made in order to find what form of conductor would give the maximum increased resistance in the variable period, and I found that an external tube of iron insulated from its central core produced this effect, for if the tube was not insulated but joined in electrical contact the results were reduced, due I believe to a transversal neutralization taking place in its own portion of the wire, as I have mentioned in my reply to the discussion on my first paper.

TABLE III.
Influence of an iron tube upon an interior insulated wire.

Iron gas tube, 90 cm. in length, 10 cm. diameter, 2 mm. thick. Wires 1 metre in length, 3 mm. diameter.	Comparative force of the extra currents.	Resistance in ohms, stable period.	Resistance in ohms, variable period.	Per centage of increased resistance in variable period.	Absolute increase of resistance in ohms.
Copper wire alone.	82	0.00460	0.00482	7	0.00022
Copper wire insulated in the interior of the iron gas tube.........	410	0.00460	0.03220	600	0.02760
Brass wire, ditto...	410	0.01380	0.03974	188	0.02594
Iron wire, ditto....	615	0.02944	0.05888	100	0.02944
Lead wire, ditto...	410	0.05750	0.08682	51	0.02932
German silver wire, ditto.......	410	0.07636	0.10384	36	0.02748

Table III shows the effect produced upon an electric conductor by surrounding it with an insulated sheath of iron. It will be seen that the magnetic reaction of the tube upon the primary current passing in the wire produces a marked effect upon the different metals, the force of the extra currents as measured by the induction balance rising in value from 82 to 410, this being a constant for all metals except iron, which alone shows the higher force of 615 ; the force of the extra currents, however, has no direct relation to the extra resistance shown in the variable period, but the latter must be in direct relation with the duration or length of time required to pass from an infinite to the stable resistance.

The table shows on comparing the resistance of a metal in its stable period with that found in the variable, that copper has the highest percentage of increased resistance, being 600 per cent. increase, or seven times that found for its stable resistance, each metal in the order of their specific resistance having a less percentage of increased resistance until we arrive at the german-silver wire, which shows only 36 per cent. against the 600 per cent. of the copper ; we have also here the remarkable fact that iron even with a circular section stands simply in its order of specific resistance, showing only one-sixth of the increased resistance experienced by copper ; the percentage of increased resistance of a metal when under the influence of an insulated magnetic sheath is directly as its conductivity or inversely as its specific resistance.

If we regard the phenomenon from a different point of view, confining ourselves simply to the additional resistance above that of its specific stable resistance, all metals whether magnetic or non-magnetic have an almost invariable quantity dependent entirely upon the coefficient of the electro-magnetic action of the iron tube, and independent of the resistance or nature of the wire.

The experiments with an insulated iron sheath may be considered as a forced condition which does not occur or need not be taken into account, but the reaction of the iron tube is evidently electro-magnetic, and as our atmosphere is also magnetic, we may assume that its reaction would be similar though in a far less degree to that which I have shown.

SUBMARINE CABLES.

The influence of a magnetic sheath upon an insulated wire is one of vast practical importance in relation to our electrical submarine cables, as they are all constructed with an insulated wire surrounded by a spiral sheath of exterior iron wires. In order to study this question I made several cables of short lengths (1 metre) and found (most fortunately for our practical applications) that when the exterior iron sheath is divided as in a cable, or when the sheath consists of several large wires in close contact, its effects are reduced to a mere fraction of what it would be if the external sheath was a continuous tube ; this is entirely due (as I have shown in the case of stranded wires as compared with solid) to the imperfect formation of circular magnetism. I will cite a few examples illustrating this: a cable was formed of a similar copper wire and insulation to that shown in table III, the iron tube being replaced by eight iron wires (of 2 mm. diameter each) wound with a slight spiral of five turns per metre: this showed but 100 per cent. increase in the force of the extra currents against 400 per cent. increase when the same wire was in the iron tube ; the increased resistance in the variable period was but 50 per cent. against 600 per cent. for the iron tube, or only one-twelfth of the additional resistance caused by the tube ; these wires were replaced by galvanized iron wire which prevented magnetic contact, and the variable resistance became much less, and when these were replaced by numerous fine iron wires the effect was reduced to the minimum found, or only 20 per cent. increased resistance in the variable period, or 30 times less than that of a solid iron tube of much less iron.

It is, therefore, evident that the circular magnetism plays an important *rôle*, and that most fortunately our cable manufacturers (without knowing the immense reaction which would be produced by a continuous sheath of iron) have constructed our cables with a protection of iron divided into several iron wires instead of a continuous iron sheath ; there are, however, many telegraph lines which in passing

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through tunnels use a continuous iron tube as the protection, and therefore such lines must feel all the deleterious effects that I have shown to be caused by the reaction of circular magnetism.

INFLUENCE OF COPPER AND IRON CORES UPON THE INDUCTION AND RESISTANCE OF COILS.

It is well known that a coil of wire has a higher self-induction than the same wire in a single loop, and that the coil has a still higher induction when we introduce an iron core. I have made, however, a series of experiments in order to measure the influence of a core upon the resistance in the variable period, and also note the influence exerted by the induced or eddy currents circulating in the core: the following table shows some comparative results.

TABLE IV

Helix formed of insulated copper wire, 1.50 metre in length, 2 cm. diameter, and 24 turns.	Comparative force of the extra currents.	Resistance in ohms, stable period.	Resistance in ohms. variable period.	Percentage of increased resistance in variable period.	Absolute increase of resistance in ohms.
Helix alone......	460	0.02632	0.02896	10	0.00264
Same with a core of solid copper.	352	0.02632	0.04013	52	0.01381
Same with a core of insulated copper wire...	460	0.02632	0.02836	10	0.00264
Same with a core of solid soft iron..	2338	0.02632	0.09870	275	0.07238
Same with a core of 445 separate fine iron wires, each 0.25 mm. diameter.......	5360	0.02632	0.04448	69	0.01816
Same with a core of silk-covered fine insulated iron wires.....	5820	0.02632	0.04075	55	0.01443

A helix was formed of an insulated silk-covered copper wire of 24 single layers, having an interior diameter of 2 cm., the object being to form a coil having as little mutual induction as possible, but which would be readily acted upon by any core of metal introduced; and in order to measure the high forces obtained an induction balance of great power and range was used, the method, however, being the same as that already described.

The helix alone showed an induction value for its extra currents of 460, and a feeble increase resistance in the variable period of but 10 per cent.; if we now introduce a core of solid copper of 1.75 cm. diameter and 5 cm. long, a great change takes place both in the force of the extra currents and the resistance in the variable period, the extra currents fall in value from 460 to 352, whilst the extra resistance is increased to 52 per cent. above that of the stable period; we have here a double and contrary effect, the reduction of the force of the extra currents and the increase in the resistance cannot be due to the magnetic nature of copper, but must be due to the induced or so-called "Foucault currents" circulating in the core; to prove this the core was replaced by another similar in every respect but cut longitudinally to its centre, the currents now ceased to circulate, and the copper core had not the slightest effect either on the extra currents or the variable resistance; this is shown in the table, where for greater precautions a core of insulated copper wires replaced the solid core. Evidently the induced current in the core was the cause of the extra resistance; work was done by the primary current, and a loss of energy at the expense of the electromotive force of the extra currents, but in doing this work a resistance was produced which was no doubt caused by the currents circulating in the core. These currents required time, passing through the variable stage and thus producing from their electro-magnetic inertia an equivalent reaction and electro-magnetic inertia in the primary coil itself. That this inertia is due to the electro-magnetic character of the current and not to an electric current considered apart, is proved by the fact (which I have verified) that when we wind a wire into a coil of several superposed layers, its electro-magnetic reactions introduce a measurable resistance in the variable period precisely similar though feebler than that which would be produced by the reaction on the conductor of a magnetic body such as iron.

The effect of a solid iron core and a bundle of iron wires on the increase of the force of the extra currents is well known, but the table shows an interesting result as to their effects on the variable resistance; the solid iron core shows a very high force of extra currents produced by its magnetic reaction on the wires of the helix, the resistance in the variable period has increased 275 per cent., and its extra currents are extremely high, as we should expect; now if the extra resistance is due to magnetic reaction alone it should increase when we are enabled to increase this reaction, but if it is due in greater part to the electro-magnetic inertia of electric currents circulating in the bar, then by preventing these currents from being formed (as we did in the case of copper) we should greatly reduce the extra resistance. This proved to be the case, for on replacing the solid iron core by a bundle of fine iron wires the force of the extra currents rose from 2338 to 5360, or more than double the force of that produced by a solid bar, whilst the resistance in the variable period fell from 275 to but 69 per cent.

It is well known that a bundle of fine wires magnetizes quicker than a solid bar, and this may have had its effect, although not more important than the suppression of the eddy currents, as the latter may be the cause of the former. The table shows that where we have suppressed these currents as far as possible by introducing a core of insulated wires containing less iron than in the previous experiment, but fully insured against eddy currents, the induction was the highest and the resistance the lowest yet found for a helix containing an iron core; the experiment proves to my mind that the extra resistance found in the three last experiments is due both to the electro-magnetic inertia of the eddy currents, and the inertia of the magnetic molecules of iron.

The experiments related in this paper have been most carefully made and verified, and from the ease and certain action as well as the invariable results obtained by the method which I have described, they should be easy to repeat by others.

If we regard the whole of these researches we cannot fail to notice certain important laws which act in the greater portion of them. I have shown: 1st. That the contiguous portions of the same current react upon each other in the interior of its own portion of the conductor similar to their known exterior reactions on separate portions of the same conductor. 2nd. That the coefficient of mutual induction is less in iron than copper wires, but that their coefficient is the same when the conductor is in the form of a ribbon. 3rd. That the inductive capacity of different metals depends on their specific resistance, on their electro-magnetic capacity for circular magnetism, and on the geometrical form of their conductors. 4th. That the inductive capacity of a conductor of magnetic metal is dependent upon the formation of circular magnetism and not upon its internal magnetic permeability. 5th. That a magnetic metal can be rendered equally free from circular magnetism as the non-magnetic metals. 6th. That we have experimental evidence of electro-magnetic inertia and the deleterious effects of eddy currents in the cores of electro-magnets.

In addition to the above effects, we have the discovery of a large increase in the ohmic resistance during the variable period, allowing us to demonstrate and measure the gradual rise of an electric current in its conductor.

In conclusion, I desire to express my warmest thanks to Lord Rayleigh, Mr. F. L. Pope, Professor Forbes, Dr. Hopkinson, Mr. W. H. Preece, Dr. Fleming, Mr. Fitzgerald,

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Professor Silvanus Thompson, and Professor Ayrton, for the important theoretical contributions they gave on the discussion of my first paper. Mr. W. H. Preece, electrician of the post office, not only gave information of great practical value, but has kindly supplied me with the wires used in these experiments. The discussion proved the necessity of the researches which I have undertaken, and the importance of an experimental determination of the self-induction of an electric current in relation to the nature and form of its conductor.

THE INSTALLATION AND MANAGEMENT OF ARC LIGHTING PLANTS.

BY J. M. ORFORD,

Superintendent of the Bridgeport (Conn.) Electric Light Co.

(Continued from page 265.)

CHAPTER IV.

THE SWITCHBOARD.

A SWITCHBOARD requires two connection posts for each machine, and two spring-jacks and plugs for each circuit, with pieces of flexible covered wire for connecting them. The spring-jacks should be on top, and the connecting posts underneath, all in full view, and easily accessible.

The wires from the machines and circuits should enter at the back of the switchboard, and be securely fastened to the terminals by a screw, the ends of the wires turned over to prevent them from drawing through. Whatever style of spring-jack is used, there should be a lug on each side, with a hole large enough to admit a round plug the size of a No. 6 wire. The plug of the spring-jack must have a handle made of hard wood, with a hole bored longitudinally from one end to the other. Run the flexible covered wire through the handle, solder it into the base of the plug, and screw the plug into the handle; the other end of the wire is to be soldered into the terminal for the machine wire. The base of the plug should not be more than two inches long. The terminal, or connection post for the machine wires, should be a piece of ⅝ round brass, one inch and a quarter long, having on one end a ¼ inch pin, a little longer than the thickness of the back-board. A nut, having a hole in its cross section for the machine wire, is screwed tight on the pin, which is passed through the back-board. The connection-post in front should have three holes in its cross section; the back hole is for the flexible wire attached to the plug, the other holes are used for various purposes to be mentioned hereafter. The wooden base on which these terminals are fixed, should be well dried, then thoroughly filled with some insulating fluid. Do not place this switchboard against a wall. Leave room to go in at the back, with one end of the space blocked up, and a door on the other. The whole affair, by the aid of a little ingenuity, can be made ornamental as well as useful. It is a safe plan to have the negative wires on one side and the positive on the other, with a clear space of twelve inches in the centre. In this way you can put a great many circuits in a small space, and make your switchboard compact. Have circuits distinctly and systematically numbered, and the machine wires the same. Great care should be taken to keep the floor round the switchboard perfectly dry and clean. The plan of some stations, and the construction of some machines, admit of the wires being run more neatly than others, but in all cases safety should be considered above everything. It seems almost superfluous to say that wires should never be laid on the floor. Where there is a basement under the machine room the wires may go through the floor, being fastened to good, large porcelain knobs screwed into the ceiling of the basement, and then brought up the back of the switchboard. The basement should be dry and have a free circulation of air. The ceiling of the machine room is a good place to run the wires, covering, and protecting them with a molding similar to that used for incandescent work. Close to the switchboard set up permanently a magneto bell, which will ring through a resistance of 10,000 ohms; near it place three connection posts similar to those used on the switchboard for the machine wires. Connect two of them with the terminals of the bell, and the third to a good ground, and cover this ground wire completely. For ordinary daily testing with the bell have two lengths of flexible-covered wire, with a round plug and handle attached to each end. These plugs should fit the holes in the spring-jacks. Every known device for increasing the insulation should be called into service in the station. It is here the potential is highest, and wherever a high potential exists, high insulation is a positive necessity. Too much attention cannot possibly be given to securing good insulation. For overhead wires testing with the magneto bell affords you some information; but, at least once a month, all circuits should be tested for insulation by a powerful battery and delicate galvanometer, and a record kept of the same. Such an instrument, for example, as a Western Union tangent, is useful for this purpose. Siemens' universal is an excellent and convenient instrument. It is delicate, compact, easily and quickly handled. For cables or underground work you require such an instrument as Thompson's reflector.

UNDERGROUND WORK.

The underground business is being rapidly pushed forward, and as people move quickly in this country it may be well to prepare for it. A Western gentleman in search of information on this subject remarked, that when he was at home he learned that all electric light wires in the east were underground, but when he came east he was told that only the wires in the west were buried. The fact is very few have had experience with underground work, and some of those who tried it have not been remarkably successful. Wires can easily be operated underground, or in beds of rivers, provided you can have proper insulation, but that insulation must be high, very high indeed, compared to what is considered good enough for overhead wires. Our manufacturers of cables are, however, quite equal to the occasion, and have proved themselves so. Experiments have been made in different parts of the country. Some have failed, others have been highly successful. If success has crowned the efforts of some, it can unquestionably be repeated. In Boston 1,200 feet of cable was laid underground as an experiment. We may suppose the parties doing this work took every precaution, so far as their experience went, to make a success of it. The conductor consisted of a No. 4 copper wire, covered with rubber insulating composition one-eighth of an inch thick, and further protected by two thicknesses of cotton braid. It appears the cable was cut in two, and formed a loop 600 feet long. The wires of the loop were laid in grooves, a foot apart, in a plank laid three feet below the pavement, and covered with another plank. The resistance of the insulation of this circuit exceeded 90,000,000 ohms when first laid. To cut a long story short, it played out. Another attempt was made with the same result. (See details on page 100 of the ELECTRICIAN AND ELECTRICAL ENGINEER for March, 1886.) The gentleman making this report states that "many underground arc-lighting circuits have received "faithful trials without obtaining satisfactory results," etc. We hope the experiments made in Boston are not reckoned among the faithful trials. We do not know during what season of the year the Boston cables were laid, but may imagine the work was done when the ground was free from frost. If a cable is buried deep enough to prevent any change in its temperature during the summer heat or winter cold, the insulation will be constant. If subjected to the heat of summer, and the insulation resistance of 1,200 feet measured 90,000,000 ohms, it would rise during frost to 250,000,000. The mean would be 170 megohms, or 40 megohms per mile. For electric light cur-

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rents this insulation was simply useless, and it is no wonder that electrolysis set in, and "vaporized and attenuated" the wire. The whole trouble here was the cable was not good enough for the purpose. The first test would have shown any one experienced in this work that it was only waste of time and money. Any one familiar with electric bell work has seen the green line where wires were laid in damp places with only a cotton covering. The positive wire is precipitated the same as the anode in electroplating, and this will invariably be the case where a current is on badly insulated underground wires. The more powerful the current the more rapid this electrolytic action will be. The only preventive is high insulation. When once electrolysis sets in the cable is doomed. A mistake was made in attempting to cover a solid No. 4 wire. A strand of small wires should have been used, and being flexible, the covering could have been more uniformly applied. Covering with cotton tape and laying in grooved planks, were actually no aid to the insulation; they simply served to protect the rubber from abrasion. An experiment was made in Baltimore with copper wire covered with terra-cotta beads, and buried in a terra-cotta split pipe, with boiling bitumen poured over them. When this was laid, the party who made the first test prognosticated that it would play out in less than a year, simply because the insulation was not high enough. In point of fact, it gave out in six months. A test was made with another cable, and the first test showed that it would endure. The cable was half a mile long, was within reach of the summer heat and winter frost. In July it tested 450 megohms; in January 1290, the mean being 870 or 435 megohms per mile, eleven times as high as the Boston cable. The object of this test was principally for durability of the insulating material under the influence of heat and cold. After it had been buried a year, it had improved, and the insulation showed in July a resistance of 500 megohms. Another instance of underground, or, more properly speaking, submarine work, may be mentioned. Two years ago, two lengths of cable, each 300 feet long, were laid in the bed of a tidal river. Unfortunately, a single No. 4 wire had been used. The core was covered with manilla, and armored with stranded No. 14 iron wire. The cables were simply dropped into the river, side by side. Instead of landing the ends carefully in a trench, they were brought up the sides of the support of a bridge, and made fast by driving large spikes on each side, at intervals of two feet. These cables are in circuit with seven miles of overhead wire, 40 to 45 lamps, and a machine with a potential at its terminals of about 2,000 volts, while the difference of potential between the cables was, and is, about 1,000 volts. After a year one of them became defective. A test was made, and the fault found where a spike pressed the armor into the insulating compound. This cable was removed, and a spare length laid in its place. As soon as the tide was in, a test was made of this new piece, and found defective. The old one was again brought into use, the fault patched, and it is working to-day. But the resistance of the insulation of these cables was nine times as high as the insulation of the Boston cables. With reference to the spare length being defective, it is due to the manufacturer to say that the reel on which it was wound was kept during a long winter standing against a steam heating pipe, and the weight of the cable pressed the armor through the compound, softened by the heat. Keep your spare cables covered with cold water. We understand, then, that the insulation for underground work must be in the neighborhood of 400 megohms per mile when the temperature is 60°, but the higher the electromotive force is carried, so must the insulation resistance be made higher in proportion. If you have a complete circuit underground you need not fear lightning, but where underground or submarine sections are inserted in overhead circuits, both ends of such sections must be carefully protected with good, large lightning arresters. Overhead circuits should have a lightning arrester on each leg, to prevent lightning going through the machine. There is not the slightest doubt that electric light wires can be successfully operated underground, but all who are interested in the business should pray that the day of visitation be delayed, as the expense will be very great, and all, or nearly all, the money already invested in the present poles and wire will be lost.

BUSINESS MANAGEMENT.

We have called attention to some of the more important points in the installation of plants, and will now turn to the management. Being fully prepared to do business you must drum up some customers. There is no need in the present state of the art, to light up a neighbor's store to see how it looks. That day has gone by. Offer your lights to the public at a fixed rate on a yearly contract, making the price fair for both parties to the contract. Those who want light for a less period, can pay a little more per month. Each lamp you own has to earn a certain sum annually, in order to pay interest on the money invested in apparatus for operating it. If this sum is divided into twelve monthly installments, the amount per month will be less than if spread over six months only. Each lamp ought to earn 60 dollars a year, exclusive of the expense of operating it. This makes for a lamp in operation twelve months $5 per month, six months $10, three months $20. To these figures add your operating expenses, per lamp, and charge accordingly. Then there is the number of hours burning. It is obvious that lamps on a circuit going out at 10 P. M., should have somewhat lower rates than those burning till midnight, and customers using the light 7 nights a week, should pay more than if using on 6 nights.

As a rule, the income will be satisfactory; the expenditure is where the strictest supervision is required. The largest items of expenditure will be in the following order—labor, coal and water, carbons, rent, oil and waste. Some stations have an item called "rebate." It should be abolished. There are stations running to-day where not a single dollar has been paid in the shape of rebate. In a properly equipped, and intelligently managed station, there is no valid reason for rebate, unless some extraordinary event happens, such as a fire, and there is nothing that will make customers so dissatisfied with the light, as when an opportunity is given them to ask for rebate. To make your light popular it must be absolutely reliable. It is no satisfaction to a customer whose store has been in darkness, if only for a minute, to be told that such and such a thing occurred. It is your business to see that accidents do not occur. Next to a light going out, a flickering, unsteady lamp is perhaps the greatest nuisance, and until you can supply a reliable, steady light, you need not expect to displace gas in stores, and make a financial success of your undertaking.

The expenses, then, should be rigidly reduced to labor, coal and water, carbons, rent, oil and waste. The labor account may fluctuate a little, being higher in winter than summer. For 200 to 250 lights running from 2 hours before sunset, till daybreak, the pay-roll should not exceed $620 per month. This makes provision for a superintendent, 2 engineers, 1 fireman, 1 lineman, 1 night inspector, and 3 trimmers. This estimate is liberal, it may be too much so. The superintendent can attend to the station and outside work, drum up customers and collect the money. There may be an advantage in having a book-keeper where the secretary is not paid, but there is very little clerical work to perform. As for purchasing material, there is nothing to purchase except coal, carbons, globes and oil, and these you can purchase by yearly contract. At 7 A. M. the lineman and trimmers should start work. With yearly contracts there will be very little changing of lamps going on, so the lineman can devote his time to keeping his poles and wires in the highest condition. The trimmers should be taught how to save carbons, by using the upper part for

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the lower, when they are long enough. When the circuits start up each one has to go over his day's work, and see that everything is all right. An hour before starting the circuits, the engineer and fireman should come on duty. The engineer should get his engines and machines ready, the fireman attends to his fires. If you have small high-speed engines there may be four of them, and eight dynamos. At 6 P. M. the night inspector comes on, and remains in the station helping round the machines unless he is called to attend to something outside. As a rule he is not called out, but about 9 P. M. he should start out over the circuits, and see how the lamps are burning. He can do this and be back in the station by midnight, at which hour the engineer and fireman go home, another engineer coming on, the two (engineer and night inspector) run the station until daybreak, when the night inspector goes home. The night engineer after breakfast, cleans the two engines and machines which were running all night. The others that were shut down at midnight, are already cleaned. It may be said that a station cannot be run in this manner. Of course it cannot be done unless everything is not only in good running order, but adapted to the work it has to perform. What attention does a good running engine require? To keep the oil cups filled is about all, and the same with a machine. The fireman has plenty of time to fill the cups on the engines, look after his fires and water, and keep the place clean. If you are provided with the appliances we have suggested, there ought not to be the least difficulty. A patrolman going up and down the streets looking at the lamps cannot do much good. The lamps if once properly adjusted and the rods kept clean, will look after themselves. If not, what is the use of them? In the same manner an engineer cannot do any particular good sitting down and attentively contemplating an engine. He may as well be instructed how to handle the machines and switchboard, and look after them as to confine his attention to his engines. By means of a good steam damper regulator the steam ought not to vary one pound the whole night, so giving the fireman an opportunity to assist round the station. The governor of the engine will take care that the speed is uniform; the regulating apparatus on the machine will take care of the current. This reduces the business to its proper place. If anything should get wrong with a machine, it gives a little warning, sufficient to admit of the spare engine being started, and before anything serious is liable to occur, the lamps are being run by another machine.

To switch a circuit from one machine to another, and maintain your lights, say No. 1 circuit is being run by No. 1 machine, and you wish to transfer it to No. 4 machine. Plug up, or let some one hold up the regulator, dial, or rheostat of No. 4. With a length of flexible covered wire, having a round plug and handle attached to each end, connect the negative of No. 1 machine to positive of No. 4. With another wire and plugs connect the negative of No. 4 machine to the negative of No. 1 circuit, and draw the negative plug of No. 1 machine from the negative of No. 1 circuit. You now have two machines in series on No. 1 circuit, with No. 1 machine generating the current. To transfer the circuit to No. 4 machine, remove the plug from the regulator of No. 4 machine, and raise the regulator of No. 1 machine as fast as a regulator generally falls, and plug it up. The two machines are still in series, with No. 4 generating the current. With a flexible wire connect the positive of No. 1 circuit with the positive of No. 4 machine, and disconnect the wires of No. 1. You will now appreciate the advantage of having terminals of wires on switchboard in full view, and accessible; also, the number of holes in same. Although it is sometimes necessary to change circuits in this manner, and place two machines in series, it is not desirable to run two machines in series for ordinary work. There is a constant tendency on the part of the stronger machine to convert the weaker into a motor, and it is only the driving power of the belt which prevents this taking place.

Those who do run machines in series have sometimes witnessed the curious phenomenon of one armature vibrating, instead of revolving, being held by the current of the strong machine from going forward, and by the belt from going backward. When two large machines of 40 or 45 lights are run in series, the electromotive force is doubled, giving a potential of 4,000 volts. Nothing destroys insulation like high potentials, so that you are assuming a great extra risk of trouble arising, a thing which should be at all times carefully avoided. Rebate is sometimes due to a dirty machine, particularly the commutator. There is nothing so well adapted to cleaning machines as waste saturated with benzine. The benzine will cut the gum-grease and dirt without destroying the insulation. Use it freely.

The coal account depends on the power your lamps require, the economy of your engines, the efficiency of your boilers and the price of coal. If you are properly equipped you can use a mixture of soft coal and screenings, in the proportion of one of the former to 2½ and perhaps 3 of the latter. Five lbs. of this mixture ought to raise steam to run a 2000 c. p. lamp one hour. Unless coal is very high priced in your town the coal bill should not exceed $125 per 100 lamps per monthly average, these lamps being city and commercial in equal proportions. Water cannot be estimated, but it is a small item. Carbons can be purchased from $10 to $20 per 1000. The quality of the cheapest is much the same as the high priced ones, they may not be so straight, but they do admirably well. The experience of the writer with carbons has been that they are all good, although some will burn away faster than others. When a lamp is not giving a steady light it is usual to attribute the cause of the flickering to the carbon. This excuse is of the same character as that of the indifferent workman who always complains of his tools. The bill for carbons, per month, throughout the year for 100 lamps, city and commercial, may be $60.

A good serviceable machinery oil can be purchased for 20 cents a gallon, and after it has gone through the bearings of the machines run it through a filter, and use on the engines and shafting, and repeat the filtering process. Where you have sight feed cups you can regulate the flow of oil to suit the quality of it, and with suitable drip pans it is no waste of oil to run it freely. The cost of machinery and cylinder oil per 100 lamps per month, should not be over $10.

A good filter can be made in this way: Take an oil tank three feet high and 18 inches diameter. Turn the bottom uppermost and cut an inch hole in the centre. Take a piece of tin pipe and solder one end in this hole, bend the pipe over, bringing the other end to the front, and solder a faucet in this. Through this pipe you can drain every drop of oil and sediment. Inside the tank, and nine inches from the bottom solder another bottom well perforated with small holes. Six inches underneath this have a faucet for drawing off the filtered oil. In this false bottom close to the wall of the tank cut a half-inch hole, and solder a pipe leading it to the top of the tank for admitting air to the oil chamber. Cover the false bottom to the thickness of one inch with gravel stones the size of an ordinary green pea. Make a bag of coarse canvas, a little more in diameter than the tank, and reaching from the gravel to the top of tank. Put the bag in the tank, and pack it firmly round the sides with animal charcoal, same as is used for case-hardening bolts, etc., to within 9 inches of the top, folding the remainder of the bag over the charcoal. Put the oil from the drip pans in this, and if the bag is large enough, and the packing round the walls of the tank as it should be, you will have a good filter. Draw your oil from the upper faucet, and occasionally clean out through the lower one. In the foregoing estimates and figures, provision has not been made for daily and expensive repairs to machines and lamps. There is no necessity for such repairs, and when they have to be made it is the result of gross carelessness. The majority of

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lamps and dynamos turned out by manufacturers in this country, are of thoroughly good design, and of excellent workmanship. Had such not been the case, the business of electric lighting would not have reached its present magnitude.

NOTES ON THE DEPOSITION OF COPPER BY DYNAMO MACHINES.

BY A. FLOYD DELAFIELD.

The current in a system composed of a dynamo, tanks and connections is found by subtracting the counter-electromotive force of the tanks from the electromotive force generated by the dynamo, and dividing the remainder by the sum of all the resistances in circuit.

The resistance of the dynamo, for the purposes of this discussion, is simply taken from its electrical efficiency. Thus, if the dynamo gives at its terminals 90 per cent. of the whole current generated, we assign it one-tenth of the resistance of the whole circuit, no matter how the field magnets may be wound.

The general equation is

$$\text{Current} = \frac{\text{Electromotive force} - \text{Counterforce}}{R \text{ of dynamo} + R \text{ of leads} + R \text{ of tanks.}}$$

With regard to the counterforce of the tanks and their resistance, I think that more trustworthy results are obtained by taking the apparent resistance of the tanks than by endeavoring to measure the real resistance and the counterforce separately. The error is small, the calculations are simplified, and meanwhile the separate measurements are generally unsatisfactory.

Now, if we denote the apparent resistance per square foot of anode in the tanks by $R^{\square}$, the area of cathode in each tank by A, and the number of tanks in series by n, the total resistance of all the tanks will be $\frac{n\,R^{\square}}{A}$.

Supposing the resistance of dynamo and leads together to be q times that of the tanks, the whole resistance of the circuit will be

$$(1+q)\frac{n\,R^{\square}}{A}$$

And if we denote the current by C, and the electromotive force by E, then

$$C = \frac{E}{(1+q)\frac{n\,R^{\square}}{A}}$$

Electrotyping and copper refining are the chief arts in which dynamos are used to deposit copper. In the first case the deposit is measured by its thickness per hour, while in refining we measure the pounds per hour.

In the first case, then, the thickness of the deposit per hour is required. A shell of copper one foot square and .001 inch thick weighs 322.55 grains. As a current of 386.4 ampères is required to deposit 1 lb. = 7,000 grains per hour, .001″ thick per square foot per hour will require 17.8 ampères per square foot.

If we call the current per square foot D, then $C = A\,D$, and if we denote the thickness of deposit per hour in thousandths of an inch by m, then $D = 17.8\,m$.

We have then

$$C = \frac{E}{(1+q)\frac{n\,R^{\square}}{A}} = A\,D, \text{ hence } E = (1+q)\,D\,n\,R^{\square}$$

$$\text{electrical h. p.} = \frac{C\,E}{746} = \frac{(1+q)\,A\,D^2\,n\,R^{\square}}{746}$$

$$= \frac{(1+q)\,An\,(17.8\,m)^2 R^{\square}}{746}, \text{ hence electrical h. p.}$$

$$= (1+q)\frac{An\,m^2\,R^{\square}}{2.3545}, \text{ and if p = per cent. mechanical}$$

efficiency, actual h. p. $= \frac{1+q}{p} \cdot \frac{An\,m^2\,R^{\square}}{2.3545}$. Here $\frac{1+q}{p}$ represents the mechanical and electrical losses.

It is plain that An is the whole cathode surface, no matter if the tanks are in series or parallel, and no arrangement of tanks can save power if q is kept the same.

With regard to $R^{\square}$, the apparent resistance of the tanks per square foot of cathode, this is obtained by passing a current through a regular electrotyping tank. The difference of potential at the anode and cathode is measured, also the deposit in a given time on one square foot.

The current per square foot is calculated from the deposit, and is equal to the number of pounds of copper deposit on the square foot per hour multiplied by 386.4. This product is divided into the number of volts difference of potential between cathode and anode; the quotient is the apparent resistance per square foot of cathode. At a temperature of 90° F., and a density of solution = 21° Beaumé, $R^{\square}$ = about .05 ohms

Example.—What horse-power must be used to deposit two-thousandths of an inch per hour in two tanks in series on 30 square feet of cathode in each tank under the following conditions:—

Dynamo; 90% electrical and 90% mechanical efficiency.
Leads; One-tenth the resistance of the whole circuit.
$R^{\square}$ = .05 ohms.

As the dynamo and leads have each .1 of the resistance of the circuit, they have .2 together, leaving .8 for the tanks. Then,

$$q = \frac{.2}{.8} = \tfrac{1}{4}, \text{ and } \frac{1+\frac{1}{4}}{.90} \cdot \frac{30 \times 2 \times 2^2 \times .05}{2.3545} = 7.08 \text{ h.p.}$$

If $m = 1\tfrac{1}{2}$, then the actual h. p. required would be

$$\left(\frac{1\frac{1}{2}}{2}\right)^2 \times 7.08 = 3.98 \text{ h. p.}$$

If it be required to determine the current and the difference of potentials at the terminals of the dynamo necessary for a given deposit, we have again

$$C = D\,A = 17.8\,m\,A.$$

If the resistance of the leads be s times that of the tanks, we have, calling the difference of potentials at the dynamo terminals E_1,

$$C = A\,D = \frac{E_1}{(1+s)\frac{n\,R^{\square}}{A}} = \frac{E_1\,A}{(1+s)\,n\,R^{\square}}$$

hence $E_1 = (1+s)\,D\,n\,R^{\square}$.

Example.—We wish to deposit at the rate of .001 inch per hour in three tanks in series, there being 10 square feet of cathode in each tank. The resistance of the leads is $\frac{1}{8}$ that of the tanks, and the tanks have a resistance of .05 ohms per square foot of cathode.

$$E_1 = (1+\tfrac{1}{8})\,17.8 \times 3 \times .05 = 3 \text{ volts},$$
$$C = 17.8 \times 1 \times 10 = 178 \text{ ampères.}$$

To determine the cross section of the leads, we have, if we call their whole length L, their resistance per lineal foot r, and their whole resistance divided by that of the tanks s,

$$L\,r = s\,\frac{n\,R^{\square}}{A}.$$

The resistance of one foot of copper of one square inch cross section may be taken at .000008 ohms, and as the resistance of a conductor is inversely proportional to its cross section, we have, denoting the cross section of the leads in square inches by $\boxed{\times}$,

$$r = \frac{.000008}{\boxed{\times}}$$

$$\text{Hence } L \times \frac{.000008}{\boxed{\times}} = s\,\frac{n\,R^{\square}}{A}, \text{ and}$$

$$\boxed{\times} = \frac{.000008\,A\,L}{s\,n\,R^{\square}}$$

Example.—The leads have $\frac{1}{8}$ the resistance of the tanks, and are 100 feet long. There are 6 tanks in series, 20 square feet cathode in each tank, $R^{\square} = .05$.

$$\text{Then } \boxed{\times} = \frac{.000008 \times 20 \times 100}{\frac{1}{8} \times 6 \times .05} = .426 \text{ square inch.}$$

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$R^{\square}$ as given in these examples is that found by measurements taken in a first-class electrotype foundry during working hours. It must be noted that $R^{\square}$ decreases somewhat as the deposit of copper becomes thicker, so that thick deposits require proportionally less power than thin ones.

In copper refining, where the weight of copper per hour is required, a different set of equations is convenient.

It is found that 386.4 ampères of current are required to deposit one pound of copper per hour. If n tanks are in series, 386.4 ampères will deposit n pounds per hour in the series of tanks, or one pound in each. If we denote by Cu the deposit in all the tanks in pounds per hour,

$$Cu = \frac{C\,n}{386.4} \text{ and } C = \frac{386.4\ Cu}{n}$$

The apparent resistance of each tank will be, as before, $\frac{R^{\square}}{A}$, and the resistance of all the tanks, $\frac{n\ R^{\square}}{A}$.

If the resistance of dynamo and leads be q times that of the tanks, the current will be

$$C = \frac{E}{(1+q)\frac{n\ R^{\square}}{A}} = \frac{E\ A}{(1+q)\ n\ R^{\square}} = \frac{386.4\ Cu}{n}, \text{ and}$$

$$E = \frac{386.4\ Cu\ (1+q)\ R^{\square}}{A}$$

The actual horse-power at p per cent. mechanical efficiency is

$$\text{actual h. p.} = \frac{C\ E}{p\ 746} = \frac{(1+q)}{p\ 746} \cdot \frac{(386.4)^2\ Cu^2\ R^{\square}}{An}, \text{ hence}$$

$$\text{actual h. p.} = \frac{1+q}{p} \cdot \frac{200.14\ Cu^2\ R^{\square}}{An}.$$

From this equation we see that as long as the resistance of dynamo and leads together maintains a constant relation to that of the tanks, the horse-power is inversely proportional to the whole cathode surface, whether this be all in one tank or in any number in series.

The power is proportional to the square of the rate of deposition.

With regard to $R^{\square}$, there are many things to be considered. $R^{\square}$ may be made as small as .02 by using hot solutions in the tanks with plenty of sulphuric acid. When the copper is nearly pure, and only refined for its precious metals, this course is advantageous; but, where impure copper is refined, the problem is a metallurgical one, and must be solved as such by suitable experiments, as other metals might be deposited with the copper if $R^{\square}$ were made too small.

It is plain that in the equation

$$\text{actual h. p.} = \frac{1+q}{p} \cdot \frac{200.14\ Cu^2\ R^{\square}}{An}$$

the factor $\frac{200.14\ Cu^2\ R^{\square}}{An}$ represents an efficiency which can never be reached; for q is always greater than O, and p is always less than 1.

Example.—It is required to deposit 100 lbs. an hour under the following conditions:—

$q = \frac{1}{4}$, $p = .90$, $R^{\square} = .03$, $An = 3{,}000$.

We have, $\frac{1+q}{p} = \frac{5}{4 \times .90} = 1.389$,

$$\frac{200.14\ Cu^2\ R^{\square}}{An} = 20.014.$$

Actual h. p. = 20.014 × 1.389 = 28 h. p.

To find the current and the volts at the dynamo terminals we have

$$C = \frac{386.4}{n}\,Cu \text{ and } E_t = \frac{386.4\ R^{\square}}{A}\,(1+s)\ Cu,$$

where E_t = volts at terminals, and s = resistance of leads divided by that of tanks.

Example.—What current and what volts at terminals must a dynamo give to deposit 100 lbs. of copper per hour under the following conditions:—

$n = 60$, $A = 50$, $R^{\square} = .03$, $s = \frac{1}{8}$.

$$C = \frac{386.4}{60} \times 100 = 644 \text{ ampères.}$$

$$E_t = \frac{386.4 \times .03}{50} \times (1 + \tfrac{1}{8}) \times 100 = 26.08 \text{ volts.}$$

Cross section of leads. The formula is the same as in the case of electrotyping.

$$\boxed{\times} = \frac{.000008\ A\ L}{s\ n\ R^{\square}}$$

Example: $A = 50$, $L = 250$, $s = \frac{1}{8}$, $n = 60$, and $R^{\square} = 0.3$. Then,

$$\boxed{\times} = \frac{.000008 \times 50 \times 250}{\frac{1}{8} \times 60 \times .03} = .444 \text{ square inches.}$$

COUNTERFORCE OF TANKS.

This force is very small; about .002 volts per tank. In experimenting on the subject, I found that copper plates in a coppering solution, which showed a counterforce, could be removed from the solution, washed in hot water, scrubbed with a brush, and returned to the solution, and still gave about the same counterforce. The solution had meanwhile been well stirred.

I conclude from this that the counterforce arises from the very different sort of surface shown by the anode and cathode. I found, further, that two pieces of copper, cut from the same sheet, when immersed in an acid or a coppering solution gave a slight current without having had any current passed through them or through the liquid. I ascribe this also to a slight difference in the respective surfaces of the pieces.

With regard to the error caused by taking the apparent resistance per square foot, and disregarding the counterforce, this is trifling in the case of electrotyping, as long as the measurements are taken with cathode surfaces in each tank nearly equal to those it is intended to use in practice.

In the case of copper refining this is also true, unless very impure anodes are to be refined. Here the counterforce calls for an increased expenditure of power which is quite appreciable.

DYNAMIC ELECTRICITY.

BY CARL HERING.

(Continued from page 227.)

CHAPTER IV.

GENERATION OF ELECTROMOTIVE FORCE IN DYNAMOS.

The primary object in a dynamo electric machine is, as was explained in chapter ii, to generate an electromotive force or electrical pressure; the resulting current, which depends on the resistance in the whole circuit through which this electromotive force equalizes itself, is, in general, of secondary importance in the construction of machines. Just as in the case of a number of batteries for strong currents, the first consideration is to develop the required electromotive force, which depends only on the chemical constituents and the number of cells; the current which they are required to give is of secondary importance, and affects only the size of the plates in permitting this current to pass through the battery itself without too much loss. If a machine has been constructed to give a certain electromotive force, the greatest current which it will be able to maintain depends, in general, only on the thickness of the wire in the machine through which this current has to pass. The current, therefore, affects the construction only in the detailed dimensions of the machine, which will be discussed under the details of construction, the present chapter being limited to the methods of generating the electromotive force.

In a dynamo electric machine the electromotive force is generated, as was shown in chapter ii, by moving a wire

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near a magnet, or through a magnetic field, and depends for its value on the amount of magnetism passed through by the wire per second, or, as it is generally stated, on the number of lines of force cut per second, or on the *rate* of cutting lines of force. If the number of lines of force could be determined, the electromotive force in volts could be calculated, one volt being generated for every 100,000,000 lines of force cut per second.

In machines this electromotive force depends on the speed with which the wire passes through the field, and on the amount of magnetism passed through by that wire; it may therefore be increased by increasing either of these. The amount of magnetism passed through by the wire may be increased by one or more of the following different ways:

First. By increasing the intensity of the magnetic field, that is, the magnetic density or number of lines of force per square inch.

Second. By increasing the size of the field of the same intensity as before, or in other words, by increasing the total number of lines of force without increasing their density.

Third. By increasing the number of armature windings, or in other words, by making successive parts of the same continuous wire pass simultaneously through the same field, by winding it in the form of a coil, and moving this coil through the field, thus generating an electromotive force in each single turn or winding of the coil. As these turns or parts of turns are, from the nature of the continuous winding of a coil, all connected in series with one another, it follows that all the small electromotive forces which are generated in each of the turns, are also connected in series with one another, thus summing all the small potentials into one large one.

Fourth. By passing the same wire in opposite directions through two fields of opposite polarities; for instance, by causing a coil of one turn to revolve between a north and a south pole, as, for instance, the coil 6-5-4-3 in figure 7, in which the motions of the parts 6-5 and 4-3 are in opposite directions, and the magnetic poles near which they are have opposite polarity. From the laws of induction, therefore, the currents in these two parts will tend to flow in opposite directions, which, as will be seen by following the current, is equivalent to inducing a current in the same direction around the coil, or in other words, the two electromotive forces generated in the two parts, 6-5 and 4-3, will be added, giving double that induced by each pole.

The electromotive force of a machine may therefore be made any desired number of volts, by simply increasing any one or all of the following: the speed, the intensity of the magnetism, the size of the field passed through in the same time, the number of times that different parts of the same wire are wound so as to pass simultaneously through the same field, that is, the number of armature windings, and lastly, the number of fields passed through by the same wire. Any desired potential, however large, could be generated at even a very low speed, if it were possible to increase the magnetism and the number of armature windings to the proper amount. The weak magnetic field of the earth might be used to generate a very high electromotive force if it were possible to increase the speed of an armature or the number of its windings, or both, to the required amounts. It is evident, however, that such machines, although giving the required electromotive force, would not be practical, on account of their abnormal proportions. As there are so many different combinations of the methods just given, by means of which the same electromotive force may be generated, and as some of these will be more practical than others, or less expensive in their application, it follows that in most cases there will be one combination which is the cheapest to construct and the most efficient under the given circumstances, and this proportion of parts it is the object of the electrical engineer to determine.

The following remarks on the different methods of increasing the electromotive force, besides those already given in connection with magnetism, and those which will follow in discussing the details of construction of magnets and armatures, may be of assistance in determining the best combination of parts under different circumstances.

The speed of the wire may be increased by increasing either the number of revolutions or the diameter of the armature, that is, the distance of the wire from the axis of rotation. The general rule in regard to speed is to make both the number of revolutions and the diameter as large as other considerations will permit, for it is evident from what was said above, that the higher the speed the less the magnetism or the number of windings on the armature, and, therefore, the smaller the machine for generating the same electrical energy. The limiting conditions for the speed are purely mechanical, and will be discussed under details of construction.

The intensity of an electro-magnet, that is, the number of lines of force per square inch, may be increased to almost any amount; but, as iron becomes saturated, the economical limit to the intensity is soon reached. If a current is passed through a solenoid, that is, an electromagnet without an iron core, it will be found that the magnetism of that coil increases slowly in proportion to the current, and it may be increased to any desired amount by simply increasing the current. If an iron core be inserted, and the same series of experiments made, it will be found that the amount of magnetism for the same current is very much greater than it was before, and that it also increases approximately proportionately to the current. But a limit is soon reached when the iron ceases to add to the increasing amount of magnetism, and it is then said to be saturated. After this point is reached the magnetism will still increase with the current, but only slowly, as in the first case of a coil without a core. This point of saturation is the degree of magnetization at which all machines should be used in practice, in order to give the greatest amount of magnetism for the smallest expenditure of iron, wire and current. If a less degree of magnetization is used the magnets are unnecessarily large, and the amount of copper wire therefore unnecessarily great. If the iron is over-saturated, then the amount of magnetism developed by a certain amount of current is not as great as it might be, and therefore the proportions are not the most economical.

From this the general rules follow: Diminish the amount of iron so that the magnets may be just at the point of saturation for the required amount of magnetism. Also, proportion the cross section of the iron at different parts of the magnetic circuit, so that it may all be saturated at once. This will be further discussed under the subject of magnets.

The size of the magnets should evidently be as small as the required amount of magnetism and the saturation limit will permit, for reasons just given. This must not be confounded with the practical rule which will be explained hereafter, namely, that the amount of magnetism should be as great as practicable, which simply means that the *amount* of magnetism, as distinguished from the number of armature windings, should be made great, but that for this given amount of magnetism the size of the magnet should not be larger than the saturation limit will necessitate, as the machine will otherwise become unnecessarily large and bulky, and the amount of wire on it will be greater than it need be.

The magnets should be of the construction best adapted to collect and concentrate all the lines of force generated by the magnet coils, into the space through which the moving wire passes, as it is evident that only those lines of force which pass through this space will be rendered useful. All the others are wasted. This subject of size and shape of magnets will be further discussed under the subject of details of construction of magnets.

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The third method of increasing the electromotive force, namely, by causing the same continuous wire to pass repeatedly through the same field, is best illustrated by the ordinary well-known Gramme armature. An iron ring, figure 6, is wound spirally with a continuous wire, the end of which is connected to the beginning, so as to make it an endless coil closed in itself. This armature is then revolved between a north and south pole, as shown in the figure. If the direction of rotation and the polarity of the magnet poles are as shown, then the currents induced in all the portions of the wire, which are between the iron ring

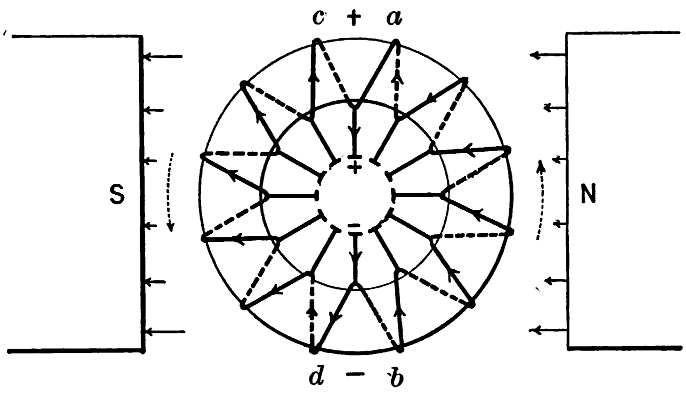

FIGURE 6.

and the north pole, will tend to flow toward the observer, according to the rules of induction, while in the wires under the influence of the south pole, the currents will tend to flow away from the observer. From the nature of the winding, it will be noticed by following the wire around the core, that the active portions between the iron ring and the pole piece, are connected in series with one another by those portions of the wire which lie in the inside of the ring, or, in other words, the same wire is wound so that it returns through the inside of the ring, and passes repeatedly through the same field. The small electromotive forces induced in each of these active parts as they pass simultaneously through the field, are therefore added in series, and at the two points *a* and *b* of that wire, where it enters and leaves the north magnetic field, the total electromotive force will be the sum of all the small electromotive forces induced in each turn. The potential which it is possible, in practice, to generate in a single wire in passing through the field once, is exceedingly small, being in most machines a small fraction of a volt, and in some exceptional (and impractical) cases a few volts. It is therefore, necessary, in all machines to cause successive parts of the same wire to pass simultaneously through the same field, in order not to have the magnets too large and costly, nor the speed too great for safe running; in other words, the armature must contain numerous windings.

As the small potentials are, from the nature of the continuous winding, all connected in series, the well-known law becomes evident, namely, that the electromotive force of such an armature is approximately proportional to the number of turns or windings of the wire around the core. Or in other words, to increase the electromotive force it is only necessary to increase the number of windings in the same proportion, provided this can be done without changing any other parts on which the electromotive force depends. This electromotive force must not be confounded with the available difference of potential at the poles of the machine when running, as mentioned in chapter iii, for the latter will not increase in proportion to the windings, as it depends on the current which is flowing and on the size of the wire; it will in all cases be less than the electromotive force.

Referring again to figure 6, we notice that in that portion *a b* of the continuous wire around the core which is under the influence of the north pole piece, the summing up of the small potentials causes the total to act at *a* and *b*, making a positive pole at *a* and a negative at *b*. In examining that portion of the same continuous wire which is in the other field, the same is the case with this difference only, that the direction of the inducted current will be the reverse, thereby causing a positive pole to be developed at *c* and a negative at *d*, which can readily be proved by applying the rules of induction given in chapter iii. The two currents, therefore, oppose each other at the two points of the wire which are not under the influence of the magnetic fields. These are the points at which the current must be led off by the usual method of applying brushes at these places, as they remain fixed in position under the same circumstances, while the wire moves. This might be done by making the wire bare at those parts which have to come in contact with the brushes, and then applying the brushes directly to the outside of the armature. But as this is not practicable, for numerous reasons, the continuous wire is connected at regular and frequent intervals to the thick, insulated bars of the collector, or so-called commutator, on which the brushes are made to bear.

The function of this collector in a Gramme ring armature, is, therefore, merely a mechanical one, to prevent the wearing off of the wires, and to present a broad contact for the brushes. It is therefore not really a "commutator," its function not being electrical, as the brushes might just as well be applied to the outside of the armature directly on the wires if they are bare, were it not for the mechanical objections.

It is evident from the figure, that in this form of winding the two halves of the continuous winding on the armature are necessarily connected in multiple arc, and therefore each half supplies the same electromotive force, but only half the current of the machine.

From the above remarks the following practical rules will be readily understood. As the two halves of the continuous wire are from the nature of the winding, connected in multiple arc, it is very important that the electromotive forces of the two halves should be equal, for if they are not, the difference between the two will, under certain circumstances, cause a reverse current to circulate in the armature wire, and as this current does not appear in the external circuit, it is lost energy which might easily have been saved. The brushes should, therefore, be directly opposite to each other, and the magnetic fields should be perfectly balanced, that is, both fields should contain an equal number of lines of force.

As the two halves of the continuous wire are in multiple arc, it follows that the real resistance of the whole armature from brush to brush, is one-half the resistance of one-half of the wire, which is evidently equivalent to one-quarter of the resistance of the whole wire. As the whole current of the machine divides into two parts in the armature, the wire need be calculated for only half the current of the machine. The two halves being in multiple arc, the total electromotive force is evidently only half that which the same amount of wire, windings, speed and field, could produce. By some writers this is considered to be a grave fault of that form of armature; a little thought will, however, show that it is not such a serious fault, as the current thereby is twice as great as the same size wire could stand alone, and therefore the electrical energy developed, or the current multiplied by the electromotive force, is the same. If the two halves could be connected in series, the wire would evidently have to be about twice as large in cross section, and therefore the whole machine would become larger. The only practical loss due to this so-called fault, is, that slightly more space is occupied by the insulation on two thin wires in multiple arc, than would be required for one thicker wire. A device has been patented for connecting the two halves of a Gramme ring armature in series, but as the small advantage gained is obtained at the

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cost of simplicity, it is no improvement on the old form of Gramme ring.

Referring again to figure 6, it will be seen that in order to permit the wire to be wound so that successive portions pass simultaneously through the same field, a portion of every winding must return from one end of the armature to the other in a space in which no induction takes place, that is in the space enclosed by the iron ring. As the lines of force which enter the iron of the ring are led through the core to the opposite field, it is evident that none will pass through the space enclosed by the ring, which has been repeatedly demonstrated with iron filings. The wire in the inside of the ring is therefore inactive, and may be considered dead resistance, because there is no electromotive force induced in it. It serves the purpose merely of connecting the two ends of the active portions which pass through the fields. For the same reason the wires at the ends of the ring are also dead, from which it follows that in many of the Gramme ring armatures, the dead wire forms from 60 to 70 per cent. of the whole armature resistance. According to the old theory of induction, this wire is not dead, and the question is, therefore, still a disputed one ; we believe, however, that the best authorities agree in saying that it is dead. A very simple experiment could readily be made to settle this important question.

To overcome this alleged fault, the ingenious method was devised, of making the return wire of each winding pass through the opposite field, instead of through the inside of the ring, thus rendering it active in generating electromotive force. This we termed above, the fourth method of increasing the electromotive force. Instead of making the iron in the form of a ring, it may then be made a solid cylinder, around the outside of which the wire is wound. It then becomes the well-known cylinder armature shown in figure 7. In this case the continuous wire,

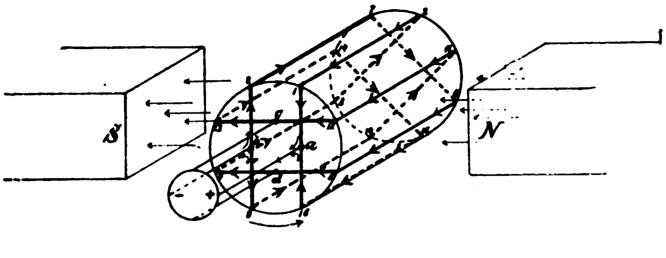


FIGURE 7.

as before, passes repeatedly through the same field. but instead of being partially in a space in which there is no magnetism, half of it lies on the other side of the armature, in the other field, in which induction also takes place. In applying the rules of induction it will be seen that the current is induced in opposite directions in the same wire, in the two fields, but upon following these two directions along the same wire, it will be seen that they are really the same direction with reference to the continuous wire itself, and that, therefore, the two electromotive forces induced in the same wire in passing through two opposite fields, are added in series. This will be seen in figure 7, by following the continuous wire around the armature, starting at 1, and thence in regular order to 8. From 9 to 16 the same will be found to be the case, only that the current in this half is opposite to that in the first half, and therefore precisely similar in this respect to the two halves of the wire in the Gramme ring. All that was said about the latter, as regards the two halves being connected in multiple arc, also applies to cylinder armatures. The only wire which can be termed dead resistance in the cylinder armature, is that at its ends. By making the armature long in comparison to its diameter, this dead wire may be reduced to a small proportion of the whole. In a recent invention even this part of the armature wire has been rendered active.

The winding of the cylinder armature, which is often represented as being very complicated, is in general very simple. It may be considered to be an ordinary Gramme ring winding, in which the wire, instead of being wound alternately on the outside and inside of the ring, is wound on opposite sides of the core, in which case, the iron ring may be replaced by a solid cylinder, as there is no longer any object in having the hollow space in the inside. The cylinder winding may also be said to be similar to the winding of a ball of twine, the wire being wound around the outside while the cylinder is being turned around slowly on its axis. In this case, as well as in the Gramme ring, the end of the wire after completing the winding, is connected to the beginning.

These two types of armature winding are given here merely as illustrations of methods for increasing the electromotive force in machines, by induction in successive parts of the same wire simultaneously, in the same magnetic field or pair of fields. They will be further discussed under the head of details of construction, where also other forms will be described.

(*To be continued.*)

ON THE SIZE OF CONDUCTORS FOR INCANDESCENT LIGHTING WHEN LAMPS ARE IN MULTIPLE ARC.

BY H. WARD LEONARD.

I.

SIZE AS DETERMINED BY A REQUIRED LOSS OF ELECTROMOTIVE FORCE IN THE CONDUCTOR.

In the various electrical text books and journals there is great dearth of practical information upon this subject. In the principal companies engaged in installing incandescent lamps, most of the employés use formulæ for the determination of the circular millage of a wire which depend directly upon the resistance of the lamp and upon some percentage of loss of the total available electromotive force, and which involve the use of a "table of constants," a different constant being required for each candle power of lamps of the same electromotive force and having the same economy, and also for each variation in electromotive force in lamps of one candle-power.

The writer, after deriving and using quite a number of different formulas, which were steps toward increased simplicity and accuracy, last year derived the formula given below, and its use by himself, and others associated with him, has been so satisfactory that he has been led to hope that it may be of assistance to some who are at present inconvenienced by the necessity of a "table of constants," which are worthless in case of a variation of candle power or economy of the lamps they apply to.

Let E = E. M. F., required to bring lamps to nominal candle-power.
" C = the current required by lamps in ampères.
" $C. P.$ = the aggregate candle power of the lamps.
" $C. H. P.$ = the economy of lamps expressed in candles per electrical horse-power.
" V = the loss of E. M. F. in the conductor both ways, expressed in volts.
" D = the distance to the lamps expressed in feet.
" M = the number of circular mils of the wire.
" R = the resistance of the wire both ways.

Since 1 watt = 44.24 ft. lbs. per minute, we have $E \times C \times 44.24$ = the ft. lbs. per minute absorbed by the lamps.

Now evidently $\frac{E \times C \times 44.24}{33000} = \frac{C. P.}{C. H. P.}$

$$C = \frac{33000 \times C.\ P.}{E \times 44.24 \times C.\ H.\ P.} \qquad (1)$$

Now the resistance of 1 ft. circular mil of copper of 96 per cent. conductivity = 10.725 ohms.

$$\therefore R = \frac{10.725 \times 2\,D}{M}$$

By Ohm's law, $C = \frac{V}{R}$

$$\therefore C = \frac{M.\ V.}{10.725 \times 2\,D} \qquad (2)$$

Now by (1) and (2) we have

$$\frac{M\,V}{10.725 \times 2\,D} = \frac{33000 \times C.\,P.}{E \times 44.24 \times C.\,H.\,P.}$$

$$\text{Whence } M = \frac{D \times C.\,P.}{V \times E \times C.\,H.\,P.} \times 16000.$$

By the substitution of the economy in candles per horse-power, we have a formula of extreme simplicity with but one constant for lamps of one economy, no matter what the variations of candle-power and the electromotive force required may be.

For example, in the case of Edison lamps which have an economy of 160 candles to the electrical horse-power, the formula becomes:

$$M = \frac{C.\,P. \times D \times 100}{V \times E}$$

And it will be noticed that in the case of lamps of 100 volts which are largely used in this system, the constant vanishes and the formula becomes:

$$M = \frac{C.\,P. \times D}{V}$$

which for simplicity it would be difficult to excel.

From the results of the Franklin Institute test, the constants for the various lamps are given in the table below; as the candle-power of the various lamps was not the same, the mean spherical candle-power is also given.

Name.	Description.	Sp. candles per el. h. p.	Mean sp. candles.	K	Relative size of conductor required.
Edison.	99 volts.	169	15.47	95	45
Stanley.	96 "	189	13.59	85	41
"	44 "	216	18.42	74	78
Woodhouse & Rawson.	55 "	210	15.64	76	64
	(2d lot.)	210	18.30	76	64
White.	50 volts.	183	12.44	87	80
Weston.	tamadine 110.5 v.	210	16.43	76	32
"	paper 70 volts.	166	15.18	100	63

II.

ON THE SIZE OF CONDUCTORS AS DETERMINED BY THE HEATING DUE TO THE CURRENT.

D = diameter of wire in mils.
M = No. of circular mils of wire area.
C = current in ampères.
R = resistance of unit length of wire.
$K, K^{I}, K^{II}, K^{III}$ = constants.
The surface of wire of unit length = ΠD
Heat radiated varies directly as ΠD
Heat generated varies as $C^2 R$
Now R varies inversely as M.

$\therefore$ heat generated varies as $\frac{C^2}{M}$

or heat generated $= \frac{C^2}{M} \times K^{I}$ where K^{I} is some constant.

Similarly head radiated $= K^{II}\ \Pi D$, and since $D = \sqrt{M}$, we have heat radiated $K^{III}\ \sqrt{M}$.

Now, since when the temperature of the wire is constant the heat generated will equal the heat radiated, we have

$$\frac{C^2 K^{I}}{M} = \sqrt{M} \times K^{III}$$

$$\therefore M^3 = C^4 \times K$$

$$\therefore M = C^{\frac{4}{3}} \times K$$

$$\text{and } C = \frac{M^{\frac{3}{4}}}{K^{\frac{3}{4}}}$$

In practice the only wires of a system of conductors for incandescent lighting in which we need expect excessive heating, are the so-called "omnibus" wires, which carry the total current, and possibly the feeders which also carry heavy currents.

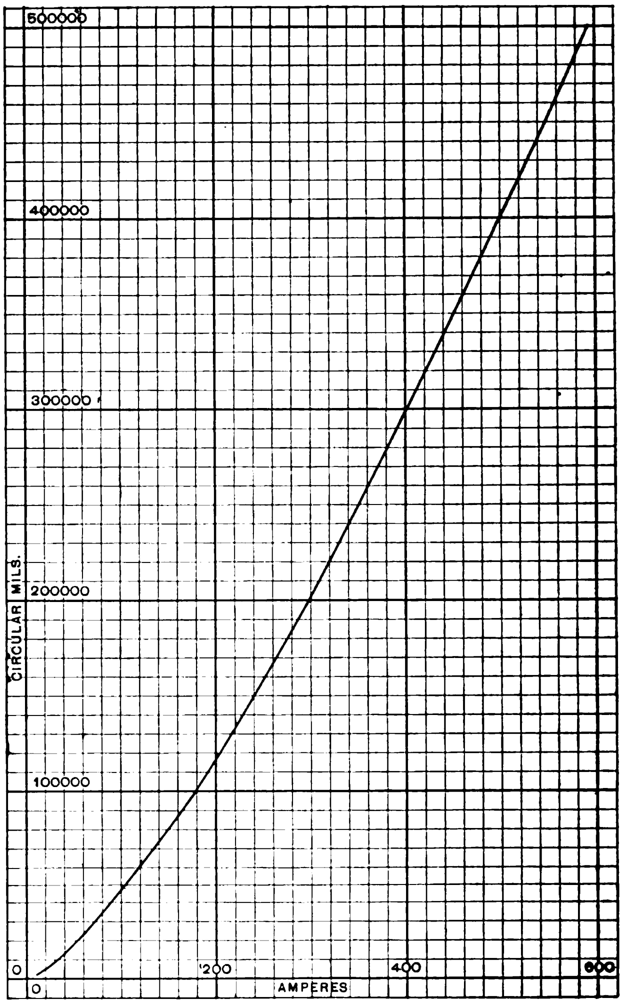
The results of some experiments on bright bare copper wire gave the value 100 for K in the above formula when the temperature of the wire was raised 81 deg. F. or 45 deg. C. That is, for such a rise of temperature as that mentioned, the formula becomes

$$M = C^{\frac{4}{3}} \times 100$$

$$\text{and } C = M^{\frac{3}{4}} \times .0316.$$

The above formula is applicable to cases when bare or insulated (which latter will be at somewhat lower temperature) wire is to be used, and is to have free access to air.

Below is given the data derived from the use of this formula as regards the size of wire for various currents, and a curve plotted from the table is also given.



CURVE OF MAXIMUM SAFE CURRENT FOR BARE COPPER WIRE.

In the case of armatures 60° C. is about the maximum safe rise of temperature admissible.

For armatures of the Siemens and similar types, the constant for 60° C. rise is 140. That is, the formula becomes

$$M = C^{\frac{4}{3}} \times 140$$

$$\text{and } C = M \quad \times .02457.$$

Chicago, Ill., May 16th, 1886.

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CORRESPONDENCE.

NEW YORK AND VICINITY.

Receiver Farnsworth Against Western Union.—Cutting a Commercial Telegram Cable.—The Movement to Introduce Telephones on the Police Telegraph.—Electric Lighting in New Jersey.—The Fort Wayne Jenney Company Gets the Orange Contract.—Electric Lighting Circuit Pulled Down in Jersey City.—The Electrical World Moves.—Building Improvements at the Stock Exchange.

IT was just a year to a day, after the Bankers and Merchants' premises were invaded and various wires cut, when the jury on July 10, brought in an award of $240,000 damages in favor of the plaintiff. Although it was generally supposed that the case would go against the Western Union Telegraph Company, fear of punishment for such an offense did not prevent the cutting of an aerial cable belonging to the Commercial Telegram Company. This act was performed by some person who climbed a pole in lower Broadway, and escaped before detection. In connection with the result of the suit brought by receiver Farnsworth, it is rumored that one of the jurymen stood out for a verdict of $50 damages, and this gave rise to a report that he had been "fixed" by representatives of the Western Union company. During the six weeks' trial no precautions were taken to isolate the jury, so that nothing but the integrity of the men, and the character of the defending corporation, appears to have stood in the way of such a transaction. The ideas of the other jurymen appear to have varied between $1,300,000 and $500,000, so that a compromise upon the sum of $240,000 was reached only after it became apparent that they would be locked up again. As the trial must have been a rather expensive affair, the judge appeared to be very anxious that it should be disposed of before dismissing the jury.

The proposition to substitute telephones for the antiquated instruments in use upon the police telegraph is meeting with some opposition on the part of those in charge of the present system. It is, however, a doubtful compliment to the police sergeants to intimate that it would take them some time to master the intricacies of a telephone system. No difficulty has been experienced in making a similar change in other cities, and when the sergeants fully appreciate the more effective manner in which they can "boss" the patrolmen through a telephone than by the slow process of spelling out on a dial, they will certainly approve of the change. The supposition that the Metropolitan company desires to hide its wires from the Subway commission under the skirts of the police telegraph, is entirely without foundation.

The various electric light systems are pretty well represented in New Jersey. The Brush, Weston, Schuyler, Edison, Westinghouse, Ball, Thomson-Houston, and probably various others, have plants in various parts of the state. Now the Fort Wayne Jenney Company has taken a contract to light Orange for an annual sum of $11,000. There were several competitors in the field.

A curious and costly accident occurred to the Ball street lighting system in Jersey City, on July 16. It appears that the authorities are not very particular in granting permits for the removal of buildings, and John Costigan undertook to move a house from Prior and First streets to 193 Bay street. On Erie street the workmen in charge of the tackle took a hitch around a convenient electric light pole, which was pulled over, bringing down the wires and short-circuiting a dynamo, burning it out instantly. It was a circuit of over 40 lamps, and the accident was so near the station that there were no intervening lamps. The company will probably bring suit against the house mover, who will, doubless, plead in defense that he didn't know it was loaded.

The former quarters of the *Electrical World*, at 9 Murray street, however suitable they may have been as a birthplace for that enterprising journal, were not properly adapted to either its present or future wants. In its new location on Park row, an elegant and commodious suite of rooms has been secured on the seventh floor of the Potter building, in the very heart of journalistic industry.

One of the most serious annoyances in connection with housetop wires in this city is the temporary or permanent changes rendered necessary by the erection of new buildings, and the additional stories placed on existing structures. Perhaps the most complex aggregation of electrical wires in the world is upon the roofs of the buildings in the block bounded by Wall, New and Broad streets and Exchange place, the location of the Stock Exchange. Owing to alterations being made in this building, a temporary roof was erected about 25 feet above the old one, which necessitated the removal of all wires crossing it. Although every apparent space was already occupied, there seems to have been room for squeezing them up, and the changes were effected by the different companies without interrupting the important electrical service in that vicinity.

NEW YORK, July 21, 1886.

PHILADELPHIA.

The "Bucket-Shops" Have Their Ticker Service Cut Off.—Instruments Removed From the Petroleum Exchange.—Experimental City Underground Work.—The Electrical Committee of Councils Cannot Get a Quorum.—Suit Against the Independent Telegraph Company.—Electrical Alarm for the Cable Road.—A New Telephone Company Chartered.

THERE is trouble brewing over the ticker service in this city. The result of the litigation between the Philadelphia Local Telegraph Company and the "bucket-shops" has at last resulted in favor of the former, and the music of the tickers in the "shops" will be heard no more. This will be a blessing in disguise to the "nobby" clerks and smart young financiers who are bent on accumulating money too rapidly, and now they will have a chance to "square" things with the boarding-house lady, tailor, *et al.* This litigation was started at the instance of the Stock Exchange, which is trying to destroy the bucket-shop business. One step further has been taken. The Commercial Telegraph Company removed tickers from the floor of the Petroleum and Stock Exchange without any previous notice. This resulted from the rivalry between the two exchanges. The Petroleum Exchange has now a private wire from the New York Stock Exchange, and quotations are posted on a board about eighteen seconds in advance of those received by ticker, so that business on the floor is not impeded. It is now proposed to establish an independent ticker service to supply members of the Petroleum Exchange in this city and the Consolidated Exchange in New York with quotations. There is talk of establishing stock exchanges at Bradford, Pittsburg and Oil City, which will be conducted under the auspices of the New York Consolidated Exchange.

The new electric lights on North Broad street from Columbia avenue to Susquehanna avenue have now been in operation for nearly a month past, and to superintendent Walker, of the electrical department, the result is most satisfactory. Councils originally made an appropriation of $2,000 at the request of superintendent Walker in order to make a test of underground electric light wires. It was decided to erect a lamp at each street corner, but after the work had been begun three citizens living in the middle of the squares between Susquehanna avenue and Berks street, submitted a proposition to Mr. Walker that if the city would erect the poles in the middle of the block they would pay for the lighting. This was accepted, and there are now ten lights between the streets named. The thoroughfare is brilliantly illuminated, and little or no trouble is experienced with the lights. When bids were asked for lighting this thoroughfare the lowest price named was 75 cents per night, while the cost now is 50 cents. At this rate the cost of the plant will be paid for in three years.

Besides the electric light wires there are buried in this conduit other wires, making a total of eight miles of wire in the underground box. These will be eventually used for other purposes by the electrical department.

Recently ten electric lights on the Lemon Hill Observatory, East Fairmount Park, were started. They are double lights, of four carbons each, of the Thomson-Houston manufacture, and are placed around the observatory 225 feet above the ground and 25 feet below the top of the tower. The globes are about 16 inches in diameter and the hoods 24 inches. They are the largest of the Thomson-Houston make, and are placed on the observatory by the Park commissioners as an experiment, this being, it is said, the first time the large lights have been constructed. The current is supplied from the Thomson-Houston manufactory at 11th and Noble streets. The lights are a decided improvement in the way of lighting this portion of the park, and for quite a distance from the tower the grounds are well lighted. I am afraid, though, the lovers who haunt this particular vicinity will protest against the introduction of these lights, inasmuch as they throw a little too much glare on their stamping ground.

Chairman Graham of the Electrical Committee of Councils, reported to the select branch a few days ago that he could not present several important matters, because he had been unable to have them considered. Mr. Graham has called three meetings of his committee and upon no occasion could he secure a quorum. There are twenty-six members of the committee, including the two presidents, and nine are required to make a quorum.

The bills referred to by Mr. Graham are those which grant permission to the Baltimore and Ohio Telegraph and the American Telegraph and Telephone companies to place their wires underground in a large number of streets. It was whispered around that a powerful telegraph corporation and an equally powerful telephone company were interested in not having the bills passed upon before the summer vacation of Councils, but no open or direct charges were made.

On June 23d an equity suit was brought against the Independent Telephone Company in Common Pleas No. 1, by Adolphus A. Knudson and T. Gardner Ellsworth. The latter are owners of patents for improvements in mechanical telephones, and they say that they sold the patents to the company for $14,500 in cash and $125,000 in stock. They allege that the company has failed to make the payments according to contract, and they ask

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the court to restrain it from doing business in the sale of state rights until they account to plaintiffs.

The Philadelphia Traction Company has introduced a new electrical alarm system on its Market street branch. It is essentially the same as the electrical department system of fire alarms. The centre of operations will be the Twentieth street station. Leaden tubes containing telegraph wires are now being fastened to the side of the large conduit in the street through which the cable passes. One cable runs east on Market street from the Twentieth street station to Front, and the other west on Market street to the depot at Forty-first street and Haverford avenue. In each man-hole along the route of the cable cars is to be placed a box containing electrical apparatus and a handle which any of the conductors can operate. If, as in a number of instances heretofore, the cable cars stop, or if the gripman should be unable to release his hold upon the cable rope, or if any other accident necessitating the stoppage of the cable should occur, the conductor, by lifting the manhole cover at any intersection, or at either of the four corners of the public buildings, can pull the handle of the box and have the engine at the Twentieth street station stopped. When the handle of the box is pulled, the alarm will be rung at the engine house, the number of taps representing the number of the man-hole from which the alarm comes. As soon as the alarm is given, the signal "E." or "W.," indicating the eastern or western end of the road, will also drop near the alarm gong, so that information as to the exact locality will be instantly conveyed.

The Westmoreland Telephone Co., of Greensburg, Pa., was chartered at Harrisburg, July 6. Capital stock $10,000.

PHILADELPHIA, July 16, 1886.

BOSTON.

Electrical Legislation by the General Court.—A Boom in Bell Telephone Stock.—Gas Companies to Engage in Electric Lighting.—Business of the Commercial Telegram Co.—Efficiency of the Police Signal System.—Blue Hill Weather Signals.—Past Operations of the Lowell Syndicate.—Municipal Electricity in Salem.—Extra Dividend of the Bell Company.

THE Massachusetts legislature has at last adjourned. It will long be remembered as one which had more bills before it relating to electrical subjects than any previous one. From the very first there were influences at work to tie up and hamper the work of the telephone companies, but good sense has prevailed and nothing done of a harmful nature. The telephone stocks were quick to feel the relief afforded them when the "general court" dissolved; the American Bell stock started from 180, and on the 14th inst was over 225. I give a slip from the Boston *Herald*, July 14th. "The boom was on in Bell telephone to-day, and to satisfy buyers it became necessary to bid the price up to 215¼, but buyers at about this figure are looking for an advance which will make this price look cheap. They say 300, for a modest guess, in the near future. Three per cent. was paid to-day for the right to call 100 shares at 230 within 60 days. The last annual report shows an income from sub-company dividends in 1885 of $597,469, against $475,401 in 1884. The income from the same source for six months of 1886 is understood to be $600,000, or more than for 12 months in 1885. Unless interrupted by legislation, this revenue will continue to increase, and, in the end, will become the company's chief source of revenue. The company is said to be earning 23 per cent. on its capital. These enormous earnings, to be more enormous later, the prospect of a 3 or 4 per cent. extra dividend and a new subscription privilege, are the bull points on Bell telephone. The street is talking 20 as the value of these subscription rights." The New England stock which had been hovering around 33, went to 38. The latter company continues to show the advantageous effects of strong conservative business methods over the haphazard wrecking style in which its various elements were inaugurated and run. I give a resume of the bills passed by the legislature relating to electrical matters. No. 206—To change the Dedham & Hyde Park Gas Company to Dedham & Hyde Park Gas and Electric Light Co. No. 225—To allow the Marblehead Gaslight Company to change its name and powers. No. 229—To authorize street railways to lease and purchase. No. 270—Bill relating to the taxation of telephone companies. No. 272—To authorize the Charlestown Gas Co. to furnish electric lights. No. 243—To incorporate the Medford Electric Light and Power Co. No. 326—Limiting the American Bell Telephone Company in their holdings of stock in other corporations. No. 327—To authorize the incorporation of the Winthrop Electric Street Railway Company. No. 337—Authorizing cable and other power. No. 349—Authorizing the Woburn Gaslight Company to furnish electric light.

The reader will notice the number of enlightened gas companies who propose to keep their stock valuable. As these gas companies usually have available land and buildings, it seems a wonder that they have not gone into the business of electric lighting before. A new company having everything to purchase cannot commence as well as a well established gas company.

The Commercial Telegram Company now has 133 tickers in use in Boston, and the number is increasing because of the greater speed of its printers compared with the old system, and the comparatively noiseless instruments now being set up. The executive officers of the company are H. J. Pettengill, general manager, and Louis Derrick, superintendent.

During the short time that the new police signal system of the Municipal Signal Company has been under trial on division 6, at South Boston, it has been a superb success, and so popular has it become with that class of citizens who are desirous of seeing law and order preserved in South Boston, that demands for more boxes have poured in from numerous localities hitherto considered dangerous places, and during the past three days eight new boxes have been set up, making a total of 33 boxes on the division at present. The police authorities have noticed that the mere presence of the boxes have a tendency to tone down turbulent neighborhoods. The silent sentries are a terror to the hoodlum, and he looks at one with awe and respect. A few days ago a drunken character felt insulted at the meek stare that one of the boxes gave him, and he struck it with his fist. He was rubbing the bruises on his knuckles, when the patrol wagon came along, hoisted him in, and before he had time to realize the situation, and before he had time to get ugly and show fight, he stood fronting the police rail at station 6, getting booked for drunkenness.

Lately there has been a general demand in various quarters for citizens' keys, and yesterday 17 keys were issued to responsible persons and firms. To each key is attached a large diamond-shaped brass tag, upon which is stamped the notice that it should be used only in cases of emergency. It is probable that 40 or 50 keys will be given out.

The Municipal Signal Company held its annual meeting last week and elected officers as follows: President, John C. Wilson; treasurer, Charles N. Barnard; clerk, C. E. Batchelder; directors, John C. Wilson, Charles N. Barnard, George W. Gregory, Albert A. Pope, Willard White, Thomas Roche and E. Hyde Rust. The company's sample precinct in South Boston is working in a satisfactory manner, and has been inspected by the police authorities of numerous cities with a view to its introduction.

South Boston does not bear an enviable reputation for law and order; when the boys break loose, more policemen are hammered there in a week than in any other part of the town in a month.

Mr. Wilson feels much elated at the success of his ingenious and effective apparatus.

The following rules will govern the display of signals at the Blue Hill Meteorological Observatory on and after July 1.

1. A red flag will indicate, as heretofore, probable rain in the vicinity.

2. Two red flags, one above the other, will indicate possible rain. This is not intended as a rain prediction, but simply to show that some of the conditions are favorable for rain.

3. The absence of red flags will indicate that no rain is expected.

4. The predictions will be made before sunset to indicate the weather expected for the following day, and will extend from midnight to midnight. The predictions will be revised each morning at eight o'clock and the signals changed if necessary.

5. A white flag with a black centre (seldom displayed in summer) will indicate an approaching cold wave.

These predictions with the exception of the last, will be independent of those of the United States Signal Service.

The hearing in the Erie telephone suits was resumed at Lowell, June 30th, after an intermission of nearly four weeks.

In the suit of William H. Bent against Erie, to recover salary as attorney, treasurer Charles J. Glidden's examination in defense was continued by Gen. Butler. He testified that Mr. Bent put into the purchase of the Northwestern company $6,250. He sold for $12,000, and also received 75 shares at 110, making his profit on the transaction about $14,000. One of the duties performed by Mr. Bent, for which he makes a charge in the suit, was to examine the limitation of the Northwestern company's contracts with American Bell. He never made an official report; but, in conversation with the directors, said he believed contracts were perpetual. In regard to the testimony of Mr. Bent that he was interested in telephone companies having an aggregate capital of $4,000,000, witness said the total was $17,000,000. Profit from deals made up an aggregate of $800,000. The profit of the syndicate on all deals previous to that was $400,000.

In the afternoon session treasurer C. J. Glidden's direct examination was resumed. Witness testified, in contradiction to Mr. Bent, that the latter did see Logan H. Roots at the meeting in New York, May 25, 1883, and with witness and Mr. Roots signed a paper together. During Mr. Bent's services he never tried a suit for the company, although it had suits. He drew up the Erie by-laws by taking the by-laws of another company and making appropriate changes. Evidence was introduced to show Bent's intimate connection in personal interest with the other members of the syndicate in their stock-watering enterprises, from the old Lowell District Telephone Company, in the purchase of the Southwestern company, one of the companies that went into the Erie. Mr. Bent was intimately connected as a

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member of the syndicate. Southwestern was bought for $700,000, intending to put it into a new company; we (the syndicate) took 3,500 shares at $50, representing $175,000.

The Salem aldermen, at a meeting June 28th, listened to the reading of a communication which the mayor had sent to the president of the Salem and Danvers street railway, in which his honor stated that blockades caused by horse cars on Essex street must be prevented, or the board will be obliged to regulate the matter. The Salem common council had a meeting in the evening. The committee on electric fire alarms recommended 4 circuits, 15 miles of wire, 4 galvanometers, 2 indicators, 25 boxes, 3 whistles, 2 strikers and a tapper in each engineer's residence, and asked for $6,000 for this purpose. The Gamewell company put in a bid of $6,900, and the George M. Stevens company one of $5,325, with extras that could be had for $600, or different boxes for $200 additional. An order for appropriating $7,000 for remodeling the present steamer house on Church street was adopted. The sum of $2,000 was appropriated for 100 electric lights for the balance of the year, to burn all night. The order appropriating $6,000 for an electric fire alarm received its final passage.

Among the new corporations are the Waltham Electric Lighting Company, capital $20,000. President, Charles C. Bills; treasurer, Elliot A. Harrington; directors, Henry N. Fisher, Alfred M. Goodale, William Roberts and Charles E. Getchell.

The directors of the Waltham Gaslight Company have voted to establish an electric lighting plant at a cost of about $20,000. Circulars will be issued to the stockholders calling a meeting for Friday, July 28, for approval of the action, and the purpose is to immediately proceed with the work. Although the bill authorizing gaslight companies to establish electric lighting in connection with its gas failed to pass the legislature, the directors claim, acting under the advice of excellent counsel, that the existing laws allow of their doing this, provided the stockholders acquiesce. The board consists of Lowell Clark, president; G. A. Stearns, treasurer; A. T. Lyman, J. R. Farnum, J. B. Gooding, directors.

It is claimed they can provide the new light cheaper than an independent company, as it is necessary for them to keep up steam night and day for the steam whistle, and they can economize fuel by using the coke produced in the manufacture of gas. The plant will be located in their present building. What effect this will have on the other proposed company, for which nearly $20,000 subscriptions have already been secured, is not known. It appears likely, however, that the white light will soon be gleaming in Waltham from one or both of these sources. The gas company thinks that its action will head off the other movement.

On the 14th the American Bell Telephone Company declared an extra dividend of 4 per cent., payable August 10, to stockholders of record July 20. This is said to be the only extra dividend to be declared this year.

BOSTON, July 15th, 1886.

CHICAGO.

Electric Light Wires on Mixed Routes.—Electric Time Out of Joint.—A New Edison Light Company.—A Chicago Tornado.—A Van Depoele Electric Railway at Pullman.

THERE has been considerable discussion here at various times, as to the portion of a pole or cross-arm which should be accorded to an electric light wire in a mixed route—a route carrying telephone or telegraph wires along with the heavier electric light conductor. The question was asked of an old lineman, and his immediate response was, put the electric light below. "Why?"

"Because if it breaks then it does not interfere with the rest of the wires."

"The rest of the wires are of iron, are they not?"

"Yes."

"And more likely to break than a copper number four?"

"Yes."

"Might they not possibly break, and fall on to the electric light wire? And as there are forty or fifty perhaps, wouldn't the top of the pole be the best place for the electric light wire, after all. Wouldn't you have less probability of mishaps from the breaking of one soft copper wire than from the breaking of one out of many iron wires?"

And it was concluded that the top was the place for the heavier conductor. Still there is another point to be considered. A soft copper wire is capable of an immense amount of stretching.

When the first telegraph lines were erected in this country soft copper was used, and it required the services of one man constantly, winding up the slack wire round the insulator. A line from Lockport to Buffalo had, when taken down, several miles of superfluous wire, but the gauge had materially lessened.

The proper place for a heavy wire might perhaps form a subject for discussion at the Electric Light Association's convention, inasmuch as it is a subject for cussing, everytime a telephone company locks horns with an electric light company.

Then there's the parallel circuit question too—Whether a line which is perfectly free from grounds will really affect a neighboring wire so as to damage it for either telegraphic or telephonic purposes, or not, is a mooted question. If perfect insulation can be shown to render an ordinary arc plant perfectly harmless, or as nearly so as Oram's time buzzer, the electrical millenium will have come—the lion and the lamb might lie down together.

By the way Oram's time buzzer got off its blooming base a few days ago—run down, or got full, or was drugged, or something, and gave out the wildest impossibilities in the way of time. It said 78 minutes past nine, along about two o'clock in the afternoon, and no two consecutive minutes appeared to belong to the same hour during most of one day. When "Old Father Time" as he is sometimes known, learned of the irregularities of the instrument it only required a few minutes to set it right again; but while it was off its record it had things pretty much all its own way. To tell the truth it lied like a $2.00 watch.

A very pretty and comprehensive book of tables has lately been issued by the Electrical Supply Co. here. The book is valuable to any one who is called upon at any time to use tables, which no one can carry in one's head Among other valuable data will be found complete formula for determining the size of incandescent wiring, contributed by Prof. H. S. Carhart, who by the way has been unanimously elected to the Chair of Physics in the Michigan University at Ann Arbor. Illinois' loss is Michigan's gain, and while the change is to be regretted by those who have met the professor frequently in Chicago, we can forego personal feeling in rejoicing with him in his preferment.

The Edison Light Company of Minonk, Illinois, was recently incorporated, with a capital of $4,000. Incorporators Miner T. Ames, D. S. Richards and C. S. Carr. By an error of the printers this was published as of Chicago, and the tremendous capital, $4,000, made plenty of wonder for people who assumed that it was a reorganization of the Edison company here.

Chicago, for the first time in a great many years had a sample tornado a few days ago, which pretty well cleaned up the Lakeside Sanitarium, an institution where little people are placed in the hands of trained nurses during the day, while their mammas are out at work. The building was struck by the tornado, lifted off, or rather lifted with, its post foundation, carried a few feet to the west, and set down. The roof blew off, but the building at the end of the shed-like portion withstood the shock, and protected the little ones and their friends. There were sixteen children in the building, and their escape was well-nigh miraculous.

The extent of the storm was something like one and a half miles along the shore south of Twenty-second street, but it did not reach inland half a mile.

An eye-witness, who described the storm to the writer, said that he distinctly marked two currents of air, one at the earth's surface in one direction, the other some distance above it and almost directly opposite in direction, so that it seemed to him that the two together made a sort of revolving brush to sweep up the earth with.

Previous to this high wind we had a severe rainstorm, sandwiched by showers of large hail. Stones as large as butternuts were picked up, and one party avers that he picked up one two and a quarter inches in diameter.

The signal service bureau had been threatening us with a hot wave for two or three days, but the thermometer has refused to acknowledge the authority of that department, and we have been having cool, pleasant weather since the storm.

The Van Depoele people have an exhibit at Pullman, in the shape of an electric railway, which is working well, and is a surprise to the majority of lookers on.

This company has several electric railways in regular operation, and the system is claimed to be successful in every particular.

CHICAGO, July 15, 1886.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICIAN AND ELECTRICAL ENGINEER, 115 *Nassau Street, New York city.*

"THE BUG IN THE QUADRUPLEX."

[57]—The "bug" in the quadruplex, to which Mr. S. D. Field refers in his communication in your last issue, is, I presume, the "bug" to overcome which, Mr. Edison devised the repeating sounder, which he named the "bug trap."

This bug is generally supposed to consist of the "kick" or false signal in the home neutral relay, that is due to the reversal of the entire distant battery. The local contact point of the neutral

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relay is placed on the back stop. Thus, when the entire distant battery is to the line, and the armature of the home neutral relay is thereby attracted, against the force of its retractile spring, to the front stop, which is a dead point, the local circuit is open When now, the distant pole changer reverses the distant battery for the purpose of reversing the polarity of the home polarized relay, it must necessarily also reverse the polarity of the home neutral relay. It is well known that the polarity of a magnet cannot be reversed without an instant of no magnetism occurring in the magnet. It is at this instant that the retractile spring of the armature of the neutral relay, very naturally, tends to draw it against the back local contact point, thus, if the contact is of sufficient duration, making a false signal. If this is the "bug" or defect referred to by Mr. Field, I do not see that one need look farther for the cause. This action of the neutral relay's armature, contrary to Mr. Field's assertion, occurs at each reversal of the entire distant battery, regardless of whether the home transmitting keys are active or at rest.

Furthermore, it is quite capable of proof that a non-magnetic resistance of from 400 to 600 ohms may, under ordinary circumstances, be instantaneously inserted or withdrawn from a long quadruplex circuit, without producing any detrimental effect upon either of the relays in the circuit. I do not say that such an operation is of any benefit to the circuit. It is on long circuits that the "bug" in question is most noticeable. Mr. Field states that the most operative devices for overcoming this defect, are those which involve a slight mutilation of the arriving signals. My experience with devices for overcoming this "defect" has been, that those devices which reduce the mutilation of the signals in the home neutral relay to the minimum, are the most successful.

I have alluded to the "bug" as a defect. It is, however, questionable whether that can be called a defect which, by the proper construction and adjustment of apparatus, may be overcome to such an extent that its existence is practically imperceptible.

WM. MAVER, JR.

Jersey City, N. J., July 22, 1886.

LITERATURE.

REVIEWS.

Electric Railways and the Electric Transmission of Power, Described in Plain Terms. By ROBERT LUCE, A.M. Boston: W. I. Harris & Co., 1886.

ALTHOUGH the idea of propelling vehicles by electricity dates back some fifty years, it did not become a practical possibility until the development of the dynamo-electric generator solved the problem of supplying the requisite electromotive force within permissible limits of cost. The dynamo gave significance and importance to many inventions made in preceding years with a view of employing the galvanic battery as the source of electrical energy, and during the last ten years the subject of electric locomotion has come into considerable prominence, and has excited much interest on the part of the general public, as well as among electricians and other scientists. There is need, therefore, for a work which promises to give such general information concerning electric railroading as will enable the public to appreciate the progress which is being made, and the difficulties which have been, as well as those which are still to be, overcome.

The subject affords ample opportunity for an exceedingly interesting work, and it is evident that Mr. Luce has spent much time and careful study in collecting facts, which are for the most part valuable and useful. After rehearsing the usual elementary primer lessons, which, for some inscrutable reason, nearly every writer upon electrical matters feels himself called upon to present, there is given a brief, but, nevertheless, interesting, history of the early electric railways, beginning with the inventions of Thomas Davenport in 1835. Following these are notices of the principal systems of electric railways now in operation abroad and in this country, descriptions which may be commended as clear and accurate. Mr. Luce is an enthusiastic and hopeful writer, and in a succeeding chapter, discussing the question of the cost and the advantages of electricity as a motive power, when placed in competition with horse railways and cable roads, the reader is left no grounds of doubt as to the great superiority of electricity. Possibly the author is visionary at times, but his prophecies are at least founded upon rational considerations.

A special branch of electric railroading, to which a chapter is devoted, is the application to the elevated railways, a subject of vital interest to the citizens of New York. The arguments the author advances in support of his statements that by its application "there will be an increase of speed, safety and cleanliness, and a decrease in smell, noise, cost and obstruction to streets," will be read with interest.

Throughout the book we find a great number of interesting and instructive facts, but it is to be regretted the author was not more painstaking in arranging and collecting his data. One of the most important requisites in a writer upon scientific subjects is the ability to organize and classify the facts he desires to make use of, and to present them in such systematic order as to render the complete work a unit. It is unfortunate, in this instance, that the author did not bestow upon the work the careful preparation which would render the book more a scientific treatise, and less a scrap-book of stray facts and newspaper articles. But aside from its incompleteness, pardonable enthusiasm, and the evident tendency of the author to consider Davenport the first and Daft the final and ultimate inventor of the electric railway, this book contains much that is useful and instructive. We trust that it may be, however, but a forerunner of something more elaborate and complete from the same author.

CATALOGUES AND PAMPHLETS RECEIVED.

The Chemical Electric Light and Power Co., have issued a large printed chart, containing a description of, and directions for using their "Volta-Pavia" battery, for operating incandescent lamps, electric motors, etc. The back of the sheet contains a comparative statement of the chemical composition, and electrical constants of the principal forms of battery in use.

Curt W. Meyer, 357 Fourth Avenue, New York, issues a very complete catalogue of physical, chemical, electro-medical, optical and scientific apparatus for amateur and professional work. In addition to ordinary forms of electrical instruments and batteries, Mr. Meyer has invented various special forms of undoubted merit, which are shown by numerous engravings. A very complete list of scientific books adds materially to the value of the catalogue.

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ELECTRICAL NEWS AND NOTES.

REPORT OF THE NEW YORK ELECTRICAL SUBWAY COMMISSION.

The following report was presented by Hon. R. P. Flower at the meeting of the commission June 30th, and was adopted:

The work of the commission is capable of being divided and subdivided into a series of questions, each of which can be provided for as it comes up by resolution of the commission. I have made certain of these divisions, which I will lay before the commission.

Some of the questions have been thoroughly considered by the commission, and I believe we are prepared to vote upon them at this time; others have not yet been considered, and I have certain propositions to make looking to our better information in respect to these.

The questions I have to propose are these:

1st. What form of subway will the commission adopt? Under this question arise the following:

(1.) Material to be used.

(2.) Form and method of placing the wires therein.

2d. How shall the subway be laid? And under this:

(1.) What particular provisions are necessary for each different kind of electrical service, and for each particular locality.

(2.) What mode of distribution shall be enforced.

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(3.) What capacity is required for each different locality.

3d. How shall the laying and maintaining of the subway be provided for, and the whole and parts thereof, and the wires therein controlled.

I am advised that the commission is not bound to accept the plans or patents of any one man or number of men, and it seems to me that each of the several questions to be acted upon by the commission should be met separately and distinctly, in order that that which is at best merely experimental may be tried in the best manner possible.

First, then, as to the form or plan of subway, its material, and the manner of placing the wires in it.

The commission have had before them many plans and forms of subway, and have devoted much time to hearing explanations and arguments and the opinions of experts. It has been a cardinal principle with them to hear every one who might present himself and desire to be heard, and they will continue to act upon the same principle as to each of the several questions before them until all are decided upon.

Nearly one hundred and fifty plans, models, &c., have been submitted to the commission, which may be classed roughly as follows:

Tunnel systems	10
Conduits formed from iron tubes or sections	10
Conduits formed from concrete, wood, or masonry	20
Sidewalk or gutter systems	20
Permanently embedded wire systems	12
Cables and insulating compounds	12

Systems not capable of being classified under the foregoing heads, mainly comprised of suggestions, alternative propositions and ideas incomplete in detail, with overhead combined systems, making up the remainder.

The commission have visited the cities of Chicago and Philadelphia and Brooklyn, and have heard full reports of the subway systems in use in Washington, Boston and Detroit, as well as in various cities in other countries—their extent and modes of construction.

The principal systems of electrical subways may be divided, first, as to their material composition, and second, as to their mechanical construction, and the manner in which the wires are placed in them.

As to material composition, subways are:

1st. Of insulating material, such as wood, glass, concrete, &c.,
2d. Of conducting material, such as iron.

As to mechanical construction, subways are, generally speaking,

1st. Tunnel systems.
2d. "Drawing-in" systems.
3d. Solid systems.
4th. "Dropping-in" systems.
5th. Combined systems.

TUNNEL SYSTEMS

or those where space is provided underground sufficient to allow the passage to and fro of men who place the wires within the subway, could be recommended, were unlimited time and money at the disposal of the commission; but the expense of such a system and the crying need of immediate action, preclude the adoption of such a plan. If ever underground railroads become a feature of our city transportation, then, perhaps, the tunnel can be used for some of the future trunk line cables.

In Paris, where the foundations of the city are honeycombed in all directions by large sewers, such a plan is practicable and admirable, but not to be thought of in New York.

DRAWING-IN SYSTEMS,

or those where man-holes are provided in the streets, connected by tubes or pipes through which the wires can be drawn, are next in prominence and convenience to tunnel systems.

In Chicago there were seen in successful operation nearly twenty miles of conduits of the "drawing-in-and-out" pattern of various materials, containing all kinds of wires, as follows:

Eight miles of the Dorsett system of concrete conduit divided into ducts, and containing in the separate ducts wires of the city telephone, telegraph and fire service, electric light wires and wires of different telegraph companies.

Four miles of the Johnstone system of iron conduit divided by metal shelves, and carrying the wires of the Postal Telegraph Company.

One mile of 3-inch iron pipes, four in number, carrying the wires of the Western Union Telegraph Company.

Three miles of iron pipes, carrying the wires of the Bankers and Merchants' Telegraph Company.

In Philadelphia a comprehensive "drawing-in" system of iron was seen, containing electric light and telephone and telegraph wires,

In Boston some two miles of such "drawing-in" iron systems are in operation.

In London 9,000 miles of wire are underground, bunched into cables and drawn into 3-inch iron pipes.

SOLID SYSTEMS,

or those where wires are permanently imbedded in insulating material and incapable of being reached except by tearing up the streets and the insulation, have been found to work with more or less success. The commissioners saw several miles of this conduit in successful operation in Chicago by the telephone company there, where wires were buried in an asphalt or coal-tar cement, laid in a wooden trough.

Several miles of similar conduit are in use in Washington for electric lighting, and there are other instances of the successful operation of this description of conduit.

In this city of New York there are several systems in use underground, each more or less satisfactory to those employing it.

A prominent example is the Brooks system used by the Metropolitan Telephone and Telegraph Company. It consists of an iron tube in which cotton-wrapped wires are drawn, and the tube filled with oil, the oil acting as an insulating medium. It is kept at a desired pressure—the tubes constantly full—by means of a stand-pipe. They use a two and a half inch iron pipe, and the system is cheap, costing less than $11 per mile of wire, because into such a pipe they can draw 300 telephone wires. Wires for telephone purposes, and those used for the American District and other call boxes, are of a very light intensity, and do not need as heavy insulation as do all other kinds. This system is claimed to give perfect satisfaction for telephone conductors.

The Western Union Telegraph Company has many wires already down in this city, laid in 3-inch iron pipes, into which they drew cables manufactured with okonite or kerite insulation. These pipes are lead-jointed, are laid in Broadway, and have manholes occasionally for taking out the wire.

To sum up as to the form of subway and the manner in which the wires are to be placed in it:

I am convinced that from the standpoint of an electrician simply, it may be said that almost any plan or system *can be made* to work; from a single lead-covered wire laid directly in the earth to a great tunnel upon whose walls the insulated conductor can be hung. Within certain broad limits, any system is electrically practicable; retardation and induction can be overcome. It is only when we face in this city the mechanical, engineering and chemical questions of interference with water-pipes, gas pipes and sewer-pipes, of obstructions from vaults, of danger from steam-pipes, of the action of sewer and illuminating gas, that the necessity for careful discrimination presents itself.

In the future, when the uses of electricity become more general, and its nature better known, it may be that the city of New York will absolutely require a grand electrical underground highway, where space can be provided for the conducting and distributing of sufficient power to run all the engines and work all the machinery within the city limits. It may be, and probably will be, that before such a space is needed, much more will be known of the qualities of different forms of electrical conductors, and of the best methods of carrying them underground, and that the matter of electrical subways will be no longer experimental, but practically demonstrated in every detail.

When such a time comes the commission or other authority will determine what is required to meet the necessities of the occasion.

The responsibilities of the present commission begin and end with providing for the requirements of their own day, and for such of the exigencies of the future as they can reasonably anticipate.

Leaving out of consideration all tunnel systems as too expensive, we must also discard any system which calls for the simple laying of insulated cables in the earth. They would not stand the chemical action of the gases and acids; the streets would be continually torn up for new connections and repairs. We are thus shut up to the question of electric subways or conduits, in which the wires or cables, insulated or otherwise, must be placed, and which once laid down should meet all the demands of the present and near future.

Of conduits it may be safely predicated that, so far as the experience of this and other cities is a test, some form or other of a "drawing-in" system is most convenient. The life of the best cable is by no means satisfactorily decided, and, of any particular cable, to predict how long it would last would be purely speculative. Of wires not contained in cables it may be said that they are equally more uncertain in their length of life and usefulness. At all events for purposes of distribution it is desirable that the wires should be easily approached at frequent intervals, and the commission cannot countenance any plan that looks to the disturbance of pavements more than is absolutely necessary.

It may be that through lines of wires would be better protected laid in permanent beds of insulating material; but a "drawing-in" conduit system allows space to be provided for new wires without the frequent tearing up of pavements.

The commission can, therefore, give their approval to a "drawing-in" system with frequent man-holes, as the general form of subway best adapted to meet the requirements of the electrical service of the present.

Passing now to the question of material, I will submit the opinion of a chemical expert whom I have employed to investigate this subject, together with such other opinions as I have been able to gather.

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Report of Dr. Albert R. Ledoux, an Expert Chemist, as to the Material for Use in Conduits.

NEW YORK, June 29th, 1886.

This problem divides itself naturally, as one examines the papers submitted to the Board, into two questions: Shall we use iron conduits, or those which are themselves non-conductors or insulators? I have given this matter the closest attention, and have arrived at the unqualified opinion that a *non-metallic material should be chosen;* not iron—for the following, among many other reasons;

1st. Expense. Iron pipes or boxes cost more than any of the concrete or cement conduits presented to the commission. A three-inch cast-iron pipe costs about 20 cents a foot, and can possibly be furnished on a very large scale for about 15 cents per foot. While tiling, board boxes, asphaltic mastics, cements and concretes can be made *of the same capacity* for from one-half to one-tenth of this cost.

2d. The next question to cost is that of durability. The experience of all city engineers has proved conclusively that iron underground is by no means as durable as iron simply exposed to atmospheric influences. Often pipes that have been down some time, although retaining their shape, are found to be eaten through and through with rust, so that the slightest blow shatters them into fragments. Moreover, a very large area of this city underground is exposed to the action of salt water. In a large number of streets, at a very short distance below the surface of the ground, the tide rises and falls, and in such localities iron is rapidly corroded.

3d. Another objection to iron pipes (electrically) is this: In all the hundreds of miles of cables or single wires which must be strung in the conduits, whatever they may be covered with, there is certain to be more or less leakage of electricity, more or less abrasion and destruction of the insulating covering of the wires. Wherever such takes place within an iron pipe, the wire is at once grounded, as is the frequent experience of the telegraph companies now using iron pipes in this city. In addition, should the insulation be weakened upon a conductor carrying the current of an arc electric light, and should this wire thus exposed come in contact with an iron pipe carrying telephone wires, or even telegraph wires, not perfectly insulated, a destructive connection is possible, which might not only injure the smaller wires, but lead into every office or every house where the telephone or telegraph wires entered; a current which is at once dangerous to life, and also liable to set fire to the structure.

4th. Again, the great expansion and contraction of iron is a disadvantage, when filled with insulated wires; and

5th. Again, the condensation of moisture within an iron conduit, unless a gutta-percha insulation is used, is detrimental.

6th. Again, an iron conduit cannot be sub-divided into separate ducts or chambers for different wires, without rapidly increasing the cost per foot, in a greater degree than when any other material is used.

Discarding iron for the reasons above stated, we have to choose between conduits of wood, cement, tiling, solid asphalt and asphaltic concrete.

The Brooklyn commission, upon which are two eminent experts, finding that with a well insulated cable any conduit can be made to work, after careful consideration did not choose iron, but first authorized a simple box trench of creosoted wood, and have made no effort to make it either gas or water tight. The result has been, to quote from their last report (see p. 6, 2d Report of Brooklyn Commission), the following:

"In its former report the Board mentioned the fact that a "conduit of creosoted wood has been successfully operated (with "telephone wires alone) in Brooklyn for nine months previously. "This conduit has since been opened and examined, and is still "in service, thus giving an aggregate test of sixteen months' "trial. Nothing was discovered by the examination above "mentioned which was unfavorable to the creosoted wood as "material for the conduit. But it was found that in some "places the lead casing of the cables had been seriously corroded "(carbonated) by carbonic acid, probably contained in the 'water "gas'—illuminating gas—which had leaked into the conduit. "This corrosion would apparently have destroyed the lead "casing, at the points where the action was most destructive, "in about eighteen months."

In fact, under the influence of dampness and steam heat, such a box becomes in time little else than a blind drain into which will percolate and stagnate more or less of the organic matter of the soil, even if ventilation prevents the accumulation of gas.

The experience of the Commercial Cable Company in this city also shows the very strong corrosive action of gas on a lead covering unprotected by an outer impervious shield.

The experience with solid conduits is claimed to be satisfactory in Chicago and Washington. When once a wire or cable so bedded becomes imperfect, it must be abandoned and can never be replaced without digging up the whole bed. And no new wires or cables can be introduced when needed without laying a new bed or re-opening the streets, or the owner must insert, once and for all, the whole number of conductors he thinks he may need at any future time, and thus incur a great and unnecessary outlay of capital.

The laborer's pick has been one of the great objections to any cement or tiling system, and it is now nowhere seriously considered.

To conclude this branch of the subject, after hearing all arguments and careful consideration, I give my unqualified approval to an asphalt concrete conduit, *provided it can be made of sufficient strength and durability, can resist the action of acids, alkalies and gases, and can be made gas and water tight,* and be in itself an insulator. As I am writing for your personal information and not for the public, I will frankly state that I have been led to this conclusion reluctantly, against my preconceived ideas, and solely by my tests, after consulting the best *disinterested* available authorities in this country. I had, until I began this investigation, the idea that an iron pipe, because now most largely used to hold a simple cable, would, enlarged, be the best form and material for a conduit.

For your guidance I will give here some of the opinions I have obtained:

Mr. R. W. Pope, associate editor of the ELECTRICIAN AND ELECTRICAL ENGINEER, who appeared before the New York commission at its request, said:

"From an electrical point of view, there can be no doubt that "a conduit should be made an insulator. In placing wires inside "a conduit of which the material is an insulator, you will have "them nearer to the present overhead conditions than in any "other way. If iron were used, you would simply bring the "wires into closer contact with the earth, which is acknowledged "to be a disadvantage. It is an accepted proposition that wires, "to be placed underground, should be well insulated, and being "so insulated, it is to their advantage to be placed in a non-conducting material; because if any injury should happen to the "insulation of the wires, they would still be protected by the "insulating material in the conduit, and so would not come into "immediate contact with the earth, as they would if in an iron "conduit.

"I speak from many years' study and experience of this "question, and am satisfied that whether for wires having metallic shields or for other forms of insulation, a conduit of an "insulating material is preferable. I am certainly in favor of "such a conduit made of an insulating material."

Mr. J. P. Davis, vice-president of the Metropolitan Telephone and Telegraph Co., said:

"I endorse what Mr. Pope has stated, that a conduit should "be made of an insulating material. When I first gave attention "to this matter, I wanted to adopt a glass tube in cement concrete, but found we could not do it satisfactorily. I have no "doubt that, as far as telephone wires are concerned, it would "be better to have them in an insulating material.

"There might be raised two objections to this material—the "first as to its durability. I have looked into that question very "closely for a year, and am satisfied on that point. Our tests "are perfectly satisfactory to us.

"The other is as to the effect of heat upon it, and I have no "doubt there is some danger there, but it is a danger that can be "guarded against where there is any liability of its coming in "contact with steam pipes. Further, I don't think the radiation "of heat from the pipes is going to be sufficient to cause injury. "I think a plank covering would be sufficient."

Mr. R. W. Pope said further: "Wires covered with gutta-"percha and drawn into the Western Union pipes, which are of "iron, are affected by heat. Iron being a conductor of heat, the "wires were injured in their insulation. This material being a "non-conductor of heat, though it might be affected on its outer "surface, would not carry the heat to the wires inside."

Mr. J. P. Davis said: "I have no doubt the material can be "protected from steam heat.

"As regards an iron conduit, I had three years' experience "with one in Boston. The longest line was about 1,500 feet, "and the moment the wires were put into use, the subscribers "complained and protested they could not hear. This was "caused by retardation. They could not get their voices through. "[Probably using the earth as a return circuit, not a metallic "circuit.—A. R. L.] A greater conductivity in the wires would "not remedy this. You could use a much longer line in a "conduit that is an insulator than in one that is a conductor.

"No amount of insulating material around the wire could "make it work as well in an iron as in an insulated conduit. "The question of retardation is a very serious one, and the use of "iron is undoubtedly a great disadvantage in that respect. The "fact is, there is no material that can be put underground that "will resist the dangers to be found there as well as one made "from the ingredients used in an asphalt conduit."

In addition to these expert opinions, I have obtained many others, and my own observation leads me to remark:

1st. In a non-conducting conduit the wires of different service are not only protected against grounding, but also against crossing or short circuiting. The very slightest electrical disturbance prohibits almost entirely communication by telephone.

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De La Rue has shown "that the strength of the electrical "current produced by an ordinary telephone in use as a trans- "mitter, is less than that which would be generated by a single "battery cell, through a line of ordinary telegraph wire six "million miles in length, and the strongest current produced by "such a telephone is only 400 thousandths as strong as that used "on a telegraph line; while a current one-millionth as strong as "the ordinary telegraph current will give distinct audible "articulation."

This being the fact, you can readily see how important it is that the telephone wire, at least, should be separated not by iron, but by thoroughly insulating material from stronger currents. The greater question of induction most serious of all electrically in a non-conducting telephone conduit can be, and has been, readily remedied by "anti-induction" cables, metal shields, coupling in metallic circuits, etc., etc., while retardation no device can entirely overcome in wires buried in an iron conduit, even if the sectional area of the conductor is largely increased.

Another advantage in an asphaltic concrete, is the readiness with which the shape of a conduit can be altered to suit any locality, the ease of repair and the durability under the conditions of our streets in New York. As to this latter point, I beg to submit the following copy of a report on asphalt concrete, made at the request of the Commissioner of Public Works:

Department of Public Works,
Commissioner's Office,
No. 31 Chambers Street.
NEW YORK, February 1, 1886.

To the Commissioner of Public Works:

Sir:

The questions you request me to answer are as follows:

FIRST.—The life and probable durability of a cement or concrete structure, principally of compounds of asphaltum, when laid under the streets of NewYork, subjected to the influences of gases and steam-heating pipes.

SECOND.—Its strength to resist strain.

THIRD.—The effect of frost.

FOURTH.—Its life as compared to cast iron.

To these inquiries I reply in the order of their tabulation, but with the express qualification that the scope and exactness of my answer is limited, owing to the omission of the purpose for which the said "structure" is intended; also that the first question is misleading—doubtless inadvertently so—in that there are no concretes used for structural purposes, so far as I am aware or am able to ascertain, of which the chief component part is "*principally* of compounds of asphaltum," that is, if the term "principally" is meant to express relative mass or bulk. I shall, therefore, assume an intended purpose for the said "structure" analogous to that of drain pipes, sewers or vault work, and also that the material is that usually known to engineers as mastic or asphaltum, and its compounds, concrete. The term "asphaltum and its compounds" has become a somewhat elastic and inclusive term, in that under it are also frequently classed any or all of the residuums of the distillation of petroleum. But without further amplification, I respectfully submit as follows:

FIRST.—That the life and probable durability of an asphaltum and its components—concrete—"structure" made to best modern specification and patents, is imperishable under the conditions named, as far as my knowledge extends, provided that the heat of steam pipes is not sufficient to melt the structure.

There are but few conditions in practice, however, where this contingency—namely, destruction by heat—could arise, as a properly compounded asphaltum concrete would be acted upon very slowly by radiant heat, certainly requiring at least 212° to render it plastic.

SECOND.—The strength to resist strain of the best compound asphaltum concretes may be calculated at the following maximums:

Crushing load, 4,000 lbs. per square inch of section.
Tensile strength, 350 lbs. per square inch of section.
This would seem to indicate ample transverse strength.

THIRD.—As the best asphaltum concrete is impervious to moisture, and is practically incapable of contraction and expansion, frost could, therefore, have no direct or appreciable effect upon it.

FOURTH.—As to its life underground compared to "cast iron." As matter of fact, *the most widely used and generally successful process of treating iron pipes for underground duty consists in thoroughly coating them with asphaltum.* Without such protection, iron underground rapidly deteriorates in some cases; much depending, however, on the conditions and locality.

I would add, that the results set forth can only be reached by rigid adherence to details, both in the material and manufacture of the concrete. For instance, I should regard it as essential, among others, that the specification for material and construction should require the use of very sharp sand, thoroughly cleansed and heated to at least 250° before and at the time of mixture; that the bitumen should have the light oils distilled at a high temperature; that the blocks or shells of the structure should be thoroughly tamped during the molding process, and that there should be sufficient compound mastic used to fill all voids or interstices, thereby forming the bond or union to solidify the mass. So formed, so far as disintegration is concerned, there is probably no more durable material used in engineering.

Yours respectfully,

J. M. BIRDSELL,
Chief Engineer, Croton Aqueduct.

EXPERIMENTS.

After arriving at the conclusion that the best material for the conduits is an asphaltic or equivalent concrete, I then determined to make with such a concrete a series of tests to ascertain whether it could be made to stand the ordeal through which a conduit should pass to overcome all the subterranean influences prevalent in this city. A theoretically perfect concrete is one in which the cementing body is in just the proper proportion to exactly fill up, when cold, the interstices in the sand or gravel which forms the base. It should resist the action of sewer and illuminating gas; it should sustain a crushing strain of 4,000 pounds per square inch, so as to support any possible weight when in position; it should be gas and water tight; not attacked by acids; uninjured by salt water; not liable to expansion or contraction; and be able either to stand the heat from steam pipes *in the severest condition* in which it may be necessary to place it, or else be susceptible of being easily and cheaply protected from heat effects that cannot be avoided.

I have had considerable experience with asphalt materials of all kinds, and the proper tests to make easily suggested themselves. I obtained several lengths of such material, and made the following analysis:

ANALYSIS.

The sample contains:

Organic and volatile matter	27.72
Sand and other mineral matter	72.28
	100.00

The organic matter contains:

Oils	5.86%
Pitch	21.86
	27.72

The mineral matter contains a small amount of metallic oxides.

The following experiments were made:

A sample was placed in a bottle kept at 75°, through which a steady current of street gas was passed for a week; at the end of that time there was not the slightest effect visible.

Another sample was suspended in salt water kept at a temperature of 100° F., with no apparent effect.

A portion of the conduit was then suspended in water with a thermometer alongside of it and the temperature raised; at 150° it began to soften, but this was only upon the outside where in contact with the water. The material is a good non-conductor of heat, and therefore at 150° the effect is only superficial. At 210° the whole mass was soft enough to be indented and pressed out of shape, while heated up to 250° it was disintegrated.

I therefore determined to make another and more thorough heat test; one which would answer the question as to the probable effect of steam pipes in the streets on an asphalt conduit: 1st, as to the effect of the heat under the severest possible test that could approximate to the most rigorous conditions that could be exacted in practice; and, 2d, to see what remedy could be applied, if necessary, to lay the conduits near a steam pipe.

I therefore had a ditch made in the earth two feet wide, three feet deep and thirty feet in length. In this I laid a 4-inch steam pipe, connected with a pair of 80 h. p. boilers, coupled. The length of pipe from the boilers to the ditch was fifty feet, while a valve upon the further end of the pipe allowed the escape of steam and the outflow of all condensed water. In this ditch I laid three lengths of conduit, as follows: One nine inches from the steam pipe, one six inches, and another three and one-half inches; between the last conduit and the pipe I stood an inch plank, and then filled the trench with sand.

Opposite each section, between it and the steam pipe, I inserted self-registering maximum, and other standard thermometers; steam was turned on at a pressure of 90 lbs., and a steady pressure was maintained, not going below this point for seven hours. At the end of this time steam was turned off, the conduits examined and the temperature noted. The maxima were as follows:

9 inches from steam pipe	96° F.
6 " " " "	104° F.
3 " " " "	134° F.
1 " " " "	190° F.
2 " " " " but protected by a board	92° F.

You will at once observe that during this length of time at no point was the temperature outside of the pipe high enough to affect the conduit, notwithstanding the fact that the pressure of

90 lbs. in the pipe is equivalent to 324° F. A single inch of intervening earth (sand) was a sufficient protector; while a plank, or coating of mineral wool, would seem all-sufficient for the most extraordinary circumstances imaginable. I must confess that I was surprised at the non-conducting power of the sand. [Near the pipe, with no sand between, the temperature was 260°.]

I am aware that the presence of moisture, the distance from the surface, etc., would materially affect the radiation and conductivity of the sand, and I therefore made the following experiment to prove absolutely the degree of heat:

I surrounded the 4-inch pipe with a board casing 18 inches in diameter, through the centre of which passed the pipe. This was filled with sand previously made absolutely dry, and the pressure maintained at 90 lbs. The maximum temperature reached in this box at a distance of 7 inches from the pipe was 97° F. during a *six* hours' test. These results, I confess, greatly surprised me, but I give them as I found them.

To determine the protection afforded by mineral wool, I wrapped a half-inch iron pipe in a half-inch coating of this material, and inserted it through a 2½-inch conduit duct. Not the slightest effect was produced by steam at a temperature of 290° when passed through this pipe for six hours. I also laid a piece of the concrete upon a bed of mineral wool ¾-inch thick, and allowed the flame of a Bunsen burner to come near the bottom of the mineral wool. The asphalt was not even softened in an hour's time.

It is, therefore, absurd to predict any danger from steam pipes to any such conduit, unless the pipes burst or are in actual contact. In these cases, the iron conduits will be equally unsatisfactory, as being such good conductors of heat, the insulation of the conductors would be destroyed.

CONCLUSION.

AS TO MATERIAL.

After a careful examination of the plans submitted to me, and after considering all the facts stated herein, I recommend an asphaltic concrete; but I also recommend the most *rigid testing* and *inspection* of the conduit while being manufactured and laid, and the exacting of guarantees from the manufacturers that their work will stand certain tests.

They should sustain a crushing strength of not less than 4,500 pounds per square inch. It should not soften materially below 160° F. It should be made of the best materials and in the best manner. During the laying a rigid inspection should be maintained.

INSULATION.

In a certain sense the commission can afford to be liberal in allowing the electric companies to use any kind of insulated conductors they prefer, but certain rules should be laid down that will insure the exclusion of untried and experimental compounds, which, should they fail, will cause the frequent reopening of conduits and cause inconvenience and trouble.

With honest inspection and full power to modify any plan adopted, and to make it conform to the exigencies which may arise, I see no trouble in obtaining a speedy compliance with the law, and one that will be satisfactory to all parties and a credit to our city. Many of the plans and devices before the commission will be found of great value when the work of laying the wires commences, and new, and possibly unexpected, problems are presented to your supervising experts.

Very respectfully submitted,

ALBERT R. LEDOUX,
M. S., Ph. D.

In addition to the above I will submit the following report of a general committee of the different electrical companies, furnished and vouched for by President Morton, of Stevens Institute, Hoboken, to the same effect, namely, that insulating materials are preferable for conduit purposes to iron tubes. This conclusion they reached after nearly a year of study and investigation.

The General Committee
on Underground Communication,
115 Broadway, Room 47.

NEW YORK, March 15, 1884.

To the Committee on Business Organization:

Gentlemen:

In pursuance of the instructions received by this committee on the seventh day of May, 1883, we beg to report:

About six hundred patents and plans relating to systems of underground electrical communication have been carefully examined.

In the search for a practicable system, consideration must first be given to the numerous plans, arrangements or constructions which have for their object the avoidance or elimination of the disturbance due to induction.

* * * * * * * * * * *

As regards a conduit, the principal requirements are that it be cheap, water-tight, have sufficient capacity, permit (without disturbing the pavement) the insertion, removal and addition of wires, and allow access for repairs and testing.

The material for, and construction of, a conduit are, in a measure, determined by the particular system of conductors it is to carry.

For an inclusive system iron is objectionable. The light conductors require to be widely separated from each other, from all other classes of conductors, and from the walls of the conduit. An iron pipe of large diameter would be required, involving great expense. Another objection to iron is that much of the current energy would be uselessly expended in setting up induced currents in the iron pipe. A third objection lies in the difficulty of securing tight joints, due to its large coefficient of expansion. A fourth pertains to its destructibility.

Various other materials have been suggested for an underground conduit—wood creosoted or coated with paraffine or asphalt, glass, porcelain, earthenware coated with asphalt, stoneware artificial stone, glazed terra-cotta, asphalt-coated terra-cotta, paper saturated with asphalt, and various compositions, such as marble dust and asphalt; sand, linseed oil and asphalt; sand, broken stone and asphalt; sulphur, sesquioxide of iron and bitumen; sand, paraffine, asphalt, with the addition of certain chemicals, etc., etc.

As far as durability is concerned, wood properly treated, is known to last underground a great many years, and could be used in the construction of a conduit. Creosoted wood is, however, injurious to gutta-percha covered wires. Earthenware or terra-cotta pipes have been used in England, and if glazed or coated with asphalt and well jointed to exclude moisture, could be used for underground service. Glass and porcelain are expensive materials. Asphalt-saturated paper could be used for the lining of passages in some forms of underground conduit. Artificial stone molded into a continuous conduit is cheap, and one of this kind was laid in 1881, in Market street, Philadelphia. In this conduit tin tubes covered with asphalt are imbedded in the artificial stone.

Terra-cotta thoroughly coated with asphalt is a cheap material, and when protected by an outer box or covering of creosoted wood is adapted for an underground conduit of the usual form. It is unaffected by changes of temperature, there is little or no difficulty in securing and maintaining tight joints, and if properly coated with asphaltum it is indestructible. As regards the compositions before referred to, the last named, consisting of asphalt, sand, paraffine, etc., is stated to be a good insulator and impervious to moisture, as well as strong and durable.

Respectfully submitted,

HENRY MORTON,
Chairman.
WILLIAM C. BEHRENS,
Secretary.

Sub-committee on electrical and mechanical devices.

In addition I will submit the report of Mr. John Thompson, the commission's expert in reference to the material to be used in conduits.

FIFTH.

Special Observations with Respect to Material.

Electrically considered, the first pair of propositions which present themselves are: Shall we endeavor to place the electric conductors in the most intimate contact with earth; or, contrariwise, shall we simulate so far as practicable the existing conditions above the surface? Upon this subject there seems to be as wide a difference of opinion between the doctors of electricity as the doctors of medicine.

Shall it be *contraria or similia?* Under each phantom subjects have died and have recovered.

If this question devolved upon the possibility, can the electric conductors under any circumstances be made to work, then there would be no controversy, for certainly they can. But in that it is apprehended the question is: How best will they operate? The answer unhesitatingly is given that an insulated conduit is best calculated to give general satisfaction, and for the following reasons among others:

Asphaltum concrete is a good non-conductor of electricity. It has practically no co-efficient of expansion. It is a good non-conductor of heat and very slowly acted upon thereby. It is cheap to manufacture. Strong, elastic, durable and generally adapted for the purpose. Hence, the wires or cables would not require to be so heavily insulated or widely separated, nor would there be liability to admit gas or moisture due to separation of joints by expansion or contraction. In the instance of the telephone wires, as effected by retardation, it offers the one fundamental remedy known for this most serious difficulty, namely, separation from earth.

Iron is an excellent conductor of electricity It has a high co-efficient of expansion. It is an excellent conductor of heat. It, therefore, would only afford mechanical protection to the wires or cables, and in view of the area of ground contact afforded each wire or cable, would thereby be brought into far more intimate electrical relations with earth than if each of said wires

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or cables were separately buried therein. This has been presented as an advantage in that induced currents would thereby be dissipated. But it is apprehended that this would tend to set up induced currents where they would otherwise not exist, and, therefore, be simply a useless waste of energy, and to that extent *increasing* the nominal retarding effect due to earth contact.

Nor has it been seriously proposed to attempt to form continuous ducts in an iron conduit without break. Such is impracticable unless a separate pipe be laid for each cable. And as it has been demonstrated in practice that but one cable can be advantageously handled in each duct, this fault is in itself a serious objection.

In support of this view of the case a few authorities and illustrations may be cited.

The Joint Committee on Underground Communication reported on December 5, 1883, that "for an inclusive system iron is objectionable."

The underground cables of Germany are laid in a trench filled with bitumen.

The underground wires of England are bunched in iron pipes; but it has been reported the telephone service so attempted has not been successful.

The Bell Telephone company put cables through iron pipes in Boston; but their engineer, Mr. Davis, has stated before this Board that the retardation was so great as to cause serious dissatisfaction among their patrons, though the extent of buried wires was limited.

Mr. Frank L. Pope, the electrical expert, endorsed a system presented to you, consisting of heavy glass tubes encased with iron.

Mr. R. W. Pope, associate editor of the ELECTRICIAN AND ELECTRICAL ENGINEER, testified before you his preference for an insulated conduit.

The cables laid about a year ago in Brooklyn, in a comparatively open ditch, formed by creosoted wood, has already proved to an extent unworthy, and concrete conduits are now being laid.

As opposed to this, but one prominent authority has taken a contending view before you, namely, Mr. T. A. Edison, who asserts that any or all wires can be made to operate successfully even when bunched promiscuously in one common iron pipe. So being, then so much the better. But while experience is not infallible as a guide to truth, it is yet fair to submit whether or no it would be wise or expedient for you to take the initiative in the adoption of a scheme generally opposed by experienced authority.

As to the term "asphaltum concrete," it is of elastic proportions, and may require to be defined. In the estimate of the writer but two elements are of controlling importance, namely, honest material and honest workmanship. The bitumen ought to be distilled at a moderately high temperature, sufficient to drive off the lighter oils, and yet not great enough to char or burn the residuum. The sand (silicious) should be perfectly clean, very sharp, of small grain, and heated to at least 220° before and at the time of mixture.

These simple elements, first thoroughly commingled, and then tamped during the molding process, forms a mass than which there is probably none more durable known to engineering, impervious alike to moisture, gases and acids.

As to the strength of this structure:

Much consideration has been given to this aspect of the case, in view of the proximity to the street surface, which it is desired to lay the conduit.

From the data on this subject, it is safe to say that asphaltum concrete can be uniformly produced offering a minimum crushing resistance equal to 4,500 pounds per square inch, and an ultimate tensile strength equal to 325 pounds per square inch of section. This would indicate ample transverse strength, particularly when it is considered that the top and bottom of the conduits are proposed to be reinforced by concrete, so that the entire mass would virtually be a monolith extending from junction-box to junction-box.

It may be stated that asphaltum concrete, in consequence of its resilient property, has been used with complete satisfaction as a foundation for steam and drop hammers, and analogous situations subjected to heavy and continued impacts.

SIXTH.

Respecting patents: This aspect of the problem has been regarded with considerable apprehension; for it may be considered as practically certain that, whatever may be the system put down, patent litigation will be likely to follow. This opinion is based upon the fact that while underground systems for conveying electric conductors are comparatively new, there has yet been a very considerable number of patents granted thereon, covering a wide range of plans, processes, and manufacturing appliances. Nevertheless, "the state of the art," and the validity of what may be regarded as generic patents have not yet been defined by the courts. No attempt has been made to act upon this subject, as, were it properly passed upon, it would require an extended and painstaking search, involving considerable expense, and at the best the result thereof would be but an opinion, with which the courts after all might not agree. And yet this is a feature of great importance which may not be disregarded.

SEVENTH AND FINALLY

A few suggestions as to supervision and rules would seem to be in order.

1. The company who may build the conduit should at once prepare and submit a working plan of such section of the city as you may select for immediate operations.

2. The survey should give the exact condition of the street or streets, and the number and kind of conductors in use.

3. All matters of detail, either as pertains to the conduit, the entrenchment, or the management thereof, to be subject to your approval.

4. It should be provided that no cable be drawn into the conduit of greater length or diameter than would enable the conduit company to handle it easily.

5. All wires entering the conduit from sources above ground should be provided with approved lightning arresters to prevent damages to their insulation by atmospheric electricity.

6. The conduit company should have absolute control of all running wires, repairs, connections, changes of every kind and character, thus enabling them to keep track, by means of maps and otherwise, of the locations and positions of all wires, branch connections, etc., etc., and thus prevent and be responsible for any interference between competitive companies.

7. The conduit company should be responsible for all damages done to cables of the different companies by reason of their neglect or other work.

8. As to any or all patents owned or controlled by the conduit company, as well as any or all patents not owned by said company, it should assume all risks of possible patent interference and litigation as against the city, the electric companies, and the commission, and should file a bond of indemnity sufficient to assure such risks

9. The commission ought also to reserve the right to make such modifications and exchanges as may occur in the future, due to the experience acquired in the accomplishment of the work and more extended and mature deliberation.

The foregoing is respectfully submitted and subscribed to as representing the most advance principles as proved, in the judgment of the writer, by preponderance of evidence and opinion.

While it appears, therefore:

1st. That any kind of conduit which will protect the insulated wires will answer, and on the other hand,

2d. That no known conduit has yet been found which works perfectly, or is an ideal one. It may be said with confidence that the weight of evidence before the commission is towards the use of an insulating material for conduits, and of insulating materials. Asphalt or bituminous concrete has certain advantage over all others, viz:

1st. It is cheap.
2d. It is durable.
3d. It is capable of standing harsh treatment.
4th. It can be easily and closely jointed.
5th. It can be made absolutely free from moisture, and free from contraction and expansion.
6th. It is a bad conductor of heat as well as of electricity.

Finally, in using asphalt or bituminous concretes for the main material of the subway, the commission can also provide metallic induction shields, or special insulation for such companies as desire, and may readily make ducts conformable to special exigencies, while preserving the principle of extra insulation in the material of the conduit intact. A conduit is nothing more electrically and mechanically than a protection for the wires within it, and a convenience for placing them underground.

It is the part of the commission to secure, to the best of their information and belief, the best and most convenient protection for the wires, and it is believed that this can be secured in an asphalt concrete "drawing-in and out" conduit, and that in the material decided upon all the advantages known to exist in any system can be successfully combined.

But in the same way as it has been said that for particular purposes or particular localities, it may be necessary for the commission to depart from the drawing-in system, so it may be said that it may be necessary for them at times to depart from the asphalt concrete material.

Iron pipes have two distinct advantages over the asphalt concrete which are indisputable. They are stronger and they are less bulky. If for special reasons extraordinary strength or compactness is preferable at special points to durability and insulating properties and cheapness, then the commission can at those points be compelled to modify their plan to suit the exigencies of the case and use iron.

Again, there are cases where it would be foolishness for the commission not to take advantage of certain circumstances which render a modification of their plan reasonable, as for instance where cable surface roads or underground roads are in process of construction, and where for an outlay much less than

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that required to lay any kind of conduit, the commission can secure a space admirably adapted to their wants.

In general, we may conclude that while we approve *the asphalt concrete drawing-in system*, other things being equal, each particular specification of the commission will have to be governed by the circumstances of the case for which it provides.

The following Resolutions were unanimously adopted by the Commission.

I.

Resolved, That the commission, in view of all the information they have been able to acquire on the subject, favor a subway which shall in the main conform to the following requirements:

(1st.) Its material shall be an asphalt or bituminous concrete which shall be capable of sustaining the following tests—Strength—It should sustain a crushing test of 4,000 pounds per square inch, and have a tensile strength of not less than 300 pounds per square inch of section. Resistance to heat and cold—It should not crack when subjected to temperature of—10°, nor lose its shape at 200°. It should not soften below 160°. Other physical properties—It should resist the action of organic acids and illuminating gas, and should not disintegrate under the action of salt water. Materials—The pitch or asphalt used should be inspected before it enters into the concrete, and be pliable at 150°, but brittle below that temperature. It should not be heated above 325° in boiling. The sand used should be silicious, and the porosity of each lot carefully determined, so as to insure the perfect cohesion of the mass—with no excess of plastic material. But this shall not prevent the use of any other material where the special exigencies of particular electrical service or of particular localities render it advisable in the opinion of the commission.

(2d.) Its form shall in general be that of a conduit with convenient man-holes where cables and insulated wires may be readily drawn in and out of distinct ducts in the conduit; but this shall not prevent the laying of wires in other ways where for special reasons it may seem desirable to the commission.

II.

That the commission may be better informed as to the necessary details of their supposed general plan.

Resolved, That Mr. Thomson, the mechanical expert of the commission, be called upon to report at the next meeting of the commission such data as he has collected as to

(1*st.*) The elaboration of the plan necessary in providing for different classes of wires; and

(2*d.*) The mode of distribution best adapted to the wires of different electrical service.

And Resolved, That the engineer of the commission be called upon to report at the next meeting of the commission such data as he has collected as to

(1*st.*) The capacity of conduit required for different classes of wires in different parts of the city; and

(2*d.*) The order in which different parts of the city can be most conveniently supplied with subways.

III.

Whereas, The commission have no funds and there are no means at present existing by which such funds can be raised by the commission, and whereas it is important that the placing of wires underground shall begin at the earliest moment possible, and whereas the commission are advised by the attorney-general of the state that they may properly engage with a construction company for the performance of this work;

Resolved, That the counsel of the commission be called upon to report at the next meeting of the commission generally as to a company to lay, operate and maintain the subway under the direction and control of the commission—and to suggest to the commission all necessary legal precautions and safeguards in the government of such company, with a general plan of contract to be made by the commission with such company—which plan, before it is adopted by the commission in any form, shall be submitted to the attorney-general for his official criticism.

IV.

That Henry S. Kearney be appointed associate supervising engineer of this commission, and that all papers relating to the locality of wires in this city, and the number in each locality, be referred to him for his assistance in preparing the report called for by previous resolutions.

V.

Resolved, That Daniel L. Gibbens be retained as counsel of this commission, and that all papers relating to the powers and duties of the commission and all proposals for the construction of subways under the direction of the commission, be referred to him for his assistance in preparing the report called for by previous resolution. Compensation to be determined hereafter.

JURISDICTION OF THE COMMISSION ON ELECTRICAL SUBWAYS.

OPINION OF COUNSEL.

To the Commissioners of Electrical Subways for the City of New York:

The resolution of the commission which calls for this report reads as follows:

"WHEREAS, The commission have no funds, and there are no means at present existing by which such funds can be raised by the commission; and

"WHEREAS, It is important that the placing of wires underground shall begin at the earliest moment possible; and

"WHEREAS, The commission are advised by the attorney-general of the state that they may properly engage with a construction company for the performance of this work:

"*Resolved*, That the counsel of the commission be called upon to report, at the next meeting of the commission, *generally as to a company*, to lay, operate and maintain the subway, *under the direction and control* of the commission, and to suggest to the commission *all necessary legal precautions and safeguards in the government of such company*, with a general *plan of contract* to be made by the commission with such company, which plan, before it is adopted by the commission in any form, shall be submitted to the attorney-general for his official criticism."

Now, while there is nothing in this resolution authorizing it, if the commission will bear with me for a few moments, I should like to state what I believe to be the position of the commission in reference to the giving of this work to a company, and why, if I understand aright, they have called on me to report *as to a company* rather than as to some other mode of having the subway built; in short, I should like to explain the preamble of the resolution as it seems to me and amplify it, so that the commission's action cannot be misunderstood, the more since certain articles have appeared in print discussing this very matter in a light somewhat unfavorable to the commission.

It is the plain duty of the commission to carry out the law which they were appointed and sworn to carry out, and not only would it be contrary to their duty for them to do what the law does not tell them to do, but equally so for them to neglect to do what it directs they shall do or to procrastinate or delay unnecessarily in doing what they have accepted as their duty.

The spirit and intent of the law are plainly and unmistakably set forth in its language.

The law provides that for a certain specified length of time it shall be the duty of the commission to examine such plans as the electric companies of this city choose to submit for putting their wires underground, and after that time if suitable plans have not been submitted it is made the duty of the commission *to cause to be devised and made ready for use, a subway conforming to the spirit of the act*, which is distinctly stated, *and to compel the different companies to use it.*

I have no hesitation in advising the commission that their duty lies in the direction of the course they are pursuing and in no other. For what other course is open to them? The attorney-general of the state has informed the commission that the subway may be built "either by contract with a private corporation or person, or, in the discretion of the commissioners, by labor employed by them."

Now as there is no provision for the commission to raise any money except for their incidental expenses and salaries, and as the intent of the law is plainly that the subway shall not be a charge upon the city or the state, the second clause of the attorney-general's remark—"by labor employed by them"—is only possible under the power which the commission have, of charging incidental and necessary expenses to the companies. While it is fair to *infer* that the commissioners under the clause allowing them this power of providing for expenses in carrying out the law are legally authorized to build the subway themselves and pay for its construction by assessment upon the companies, it is not so explicitly stated in the act as to free the question from all doubt, and the experience of the commission in the matter of payments by the companies has not been such in the past as to warrant the expenditure of so large a sum of money on a mere inference, and furthermore, there is no occasion for the commission to proceed in such a way as would perhaps render them individually liable for whatever expenses might be adjudged outside of the words "necessary and incidental," provided they can find another way equally good not open to this objection.

Reverting to the first clause of the opinion, "*by contract with a private corporation or person*," it becomes necessary to inquire what valid consideration the commission can proffer to such corporation or person for building the subway. Plainly the commission cannot bind the city or state—plainly they cannot bind the electric companies to pay for the subway (except again under the right that is granted of charging them with necessary expenses of the commission in carrying out the law), though they can by the terms of the act, compel them to use it.

It remains for them to proffer the exercise of this compulsory power of theirs as consideration for the promise made by the construction company, and this they propose to do.

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It has been affirmed that the commission could make such a contract as would give the different electrical companies the right—if they so elected—to purchase certain portions of the space of the subway which they respectively need outright; but it must be borne in mind that the companies have had an opportunity to build and own subways and have failed to do so.

It has also been said that the law should simply provide that the commission should compel the companies to put their wires underground, each in its own subway, made to conform to the plans of the commission; and furthermore, that the law ought to provide that the city shall in some way be assured of a revenue from the subway, and again that the law should provide that the subway should be owned by the city and should comprehend water pipes and gas pipes, and should provide many other things which would be to the advantage of the city or of the companies.

However, the law does not provide any of these things. It does not provide any means out of which the subway can be built, and it gives the commission no choice whatever but to make the best bargain it can for the city and the companies with whomsoever, in return for the commissioners' promise to do everything in their power to compel the use thereof, may be willing to contract to build and maintain the plan you have adopted. It is not the part of the commission or its officers to criticise the law or the way it is drawn. It is not their part to say in what respect it may be improved. But it is your plain duty, a failure in which would be inexcusable, to conform, so far as is in your power, to the intent of that authority which created your office, "which is to convert the overhead systems of electric wires and cables now in use to underground systems, as soon as possible, without impairing the efficiency of their service."

The question of the validity or the invalidity of the law creating the commission and from which it derives its powers, is one, of course, with which the commissioners have nothing to do as far as their own action is concerned.

But as such question would probably be raised by those persons contemplating the organization of a company to build the subway proposed, I thought it wise to examine this question with some care, and it would seem that the matter is no longer in doubt.

That the police power of the state extends to making regulations promotive of domestic order, morals, health and safety, has been established by an uninterrupted course of decisions by the courts of last resort in the several states and in the supreme court of the United States; and this principle would justify exclusion of property dangerous to the property of citizens of the state, and the passage of sanitary laws and laws for the protection of life, liberty, health or property within its borders.

R. R. Co. *vs.* Husen, 95 U. S., 465 (471,472),

or to prohibit the use of a dangerous article within the state, as an illuminating oil, even though patented.

Paterson *vs.* Kentucky, 97 U. S., 501.

The state has a right to control the use of a poison although patented.

Weber *vs.* Virg., 103 U. S., 344.

So the power to regulate manufacture of naphtha and oils is purely in police powers of the states, and congress has no power to regulate them therein.

U. S. *vs.* De Witt, 9 Wall., 41.

This power extends to the protection of the lives, limbs, comfort, and quiet of all persons, and the protection of all property within the state. So a state statute requiring railroad companies to maintain cattle guards is valid.

Thorp *vs.* Rutland and Burlington R R. Co., 27 Vt., 149.

This power also enables the state to regulate the charges within its borders for the use of an article even though patented.

Hockett *vs.* State, 5 Northeastern Rep., 178.

All rights are held subject to police powers of the state, and if the public safety or the public morals require the discontinuance of any manufacture or traffic the legislature may provide for its discontinuance notwithstanding the owners may suffer. So that where a company was chartered for the purpose of brewing beer, the supreme court of the United States held that the passage of a prohibitory law preventing the manufacture of beer was a competent one for the state to make and was valid as against brewing companies

Beer Co. *vs.* Mass., 97 U. S., 25.

And the state is not inhibited from enacting police regulations which operate upon instrumentalities or articles of commerce, provided no discriminations are made against classes of citizens and no restrictions placed upon commerce. Thus a statute requiring persons offering patents for sale to file a copy thereof with an affidavit of validity was held good.

Brichill *vs.* Randall, 102 Ind., 528.

There is another principle applicable to the present case which gives additional strength to the contention here made, which is that when the owner of property devotes it to a use in which the public have a use he must submit to be controlled by the public for the common good. And property becomes clothed with a public interest when used in a manner to make it of public consequence and affect the community at large.

Munn *vs* Ill., 94 U. S., 113.

And all persons using electric conductors will probably be regarded in legal contemplation as devoted to public use.

State *vs.* Nebras. Tel. Co., 22 N. W. Rep. 237.
State Mo. *vs.* Bell Co., 23 Fed. Rep., 539.
State *vs.* Tel. Co., 36 Ohio, 296.
Amer. Rapid Tel. Co. *vs.* Com. Tel. Co., 44 Am. Rep., 237.

And in this state the same principle has been laid down with emphasis by the Court of Appeals, who says: "It is a bold assertion to say in this day that there is anything in the state or United States constitution conflicting with or setting bounds upon the legislative discretion or action in directing how, when and where a trade shall be conducted in articles intimately connected with the public morals or public safety, public prosperity, or indeed to prohibit and suppress such traffic altogether if deemed essential to effect those great ends of good government.

Board of Excise *vs.* Barrie, 34 N. Y., 657 (666).

The following additional cases will show how widespread and well-settled these principles are:

Chicago R. R. *vs.* Iowa, 94 U. S., 155. Peik *vs.* R. R. Co., *id.*, 164. *Id.*, *vs.* Ackley, *id.*, 179. Winona R. R. *vs.* Blake, *id.*, 180. R. R Co. *vs.* Richmond, 96 U. S., 521 (holding that an ordinance prohibiting use of steam engines in the city is valid). R. R. Co. *vs.* Fuller, 17 Wall, 500 Olcott *vs.* Supervisors, 16 Wall, 678. Spring Val. Water Works *vs.* Schlotter, 110 U. S., 347. Ruggles *vs.* People, 91 Ill., 256. *Id.*, 108 U. S., 526. Ill. Cent. R. R. *vs.* People, 108 U. S., 541. Allmitt *vs.* Inglis, 12 East., 527. Mayor *vs.* Yuille, 3 Ala. (N. S.), 137. N. J. Nav. Co. *vs.* Bank, 6 How., 344. Com. *vs.* Duane, 98 Mass., 1. Com. *vs.* Tewksbury, 11 Metc., 55. Com. *vs.* Alger, 7 Cush., 53 Slaughter House Cases, 16 Wall., 36. Thorpless *vs.* Mayor, 21 Pa., 147. Grant *vs.* Courter, 24 Barb., 232. Bartemeyer *vs.* Iowa, 18 Wall, 129. Ogden *vs* Saunders, 12 Wheat., 213. Paterson *vs.* Com., 11 Bush., 311. Sibbons *vs.* Ogden, 9 Wheat., 1, 2, City of N. Y. *vs.* Miln, 11 Peters, 102. State *vs.* Teleph. Co., 36 Ohio, 296. (38 Amer. Rep., 586). Jourdan *vs.* Dayton, 4 Ohio, 295. Fry *vs.* State, 63 Ind., 552. People *vs.* Russell, 49 Mich., 617 (14 N. W. Rep., 568). Thompson *vs.* Staats, 15 Wend., 395. Martinetti *vs.* Maguire, 1 Deady, 216. Vammini *vs.* Paine, 1 Harr., 65. License Tax Cases, 5 Wall., 462. Palmer *vs.* State, 39 Ohio, 236 W. U Tel. Co. *vs.* Pendleton, 95 Ind., 12. Indianapolis, &c., R. R. *vs.* Kercheval, 16 Ind., 84. W. Va. Co. *vs.* Oil Co., 5 W. Va., 382. State *vs.* Perry, 5 Jones, 252. Attorney-General *vs.* R. R. Co.'s, 35 Wis., 425. Foster *vs.* Kansas, 112 U. S., 201. Toledo Agricultural Works *vs.* Work, 70 Ind., 258. Kent's Com., 340.

It would thus seem clear that the legislature has, in passing the laws in question, in nowise exceeded its powers in that those laws are binding upon all persons, and it may be further asserted with confidence that, the power being so plainly in the state and the disposition of the state being so plainly that the wires shall be put underground, the state will not allow its purpose to fail for lack of such additional legislation as may be necessary, if any such additional legislation is necessary, but will support and confirm the commissioners in what they may impartially and honestly decide to be the best method of carrying out the state's intention as it appears in the act.

I.

I have taken it that the language of your resolution—

"*Generally as to a company to lay, operate and maintain the subway under the direction and control of the commission*," indicates that you desire to be informed:

1st. Whether a company already existing can be empowered for the purpose.

2d. Whether a company not existing can be formed for the purpose.

3d. Whether the control of the underground system can be kept in the hands of the commission.

4th. Whether the company can issue mortgage bonds for the money required in the work.

5th. Whether the commission can convey the power to lease space in the subway to the company.

Chapter 499, laws of 1885, creates a commission charged with the duty of carrying out the provisions of chapter 534 of the laws of 1884.

By section 4, of chapter 499, laws of 1885, it is provided that if no suitable plan is proposed or in use within sixty days of the passage of the act, it shall be the duty of the board to cause to be devised and made ready for use such a general plan as will meet the requirements of said act. *By this act the board is given full authority to compel all companies operating electric wires to use the subway prepared in accordance with the provisions of the act.*

It would therefore appear that inasmuch as no such suitable plan was proposed or in use within sixty days after the passage of said act, the board is authorized and it is its duty to cause a general plan to be devised and made ready for use to carry out the purposes of said acts; and it would seem that this can be done by the commission itself, or by its duly authorized agent, whether such agent be an individual or a corporation, and the

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attorney-general has (as already stated) advised you to the same effect, for he says: "The construction of such subway may be had either by contract with a private corporation or person, or in the discretion of the commissioners, by labor employed by them."

In order to authorize a corporation to act as agent of the board for such a purpose, such corporation must, of course, have power, either expressed in its charter or necessarily implied therefrom, to do the acts necessary to properly fulfill the purposes of the laws above mentioned.

Among those purposes are the building of a suitable subway into which all electrical conductors may be placed, and to maintain and operate the same after being built.

It is probable that the provisions of the laws above mentioned are sufficient to allow any company existing and operating electric conductors at the time of their passage to build, maintain and operate such subways, but the question might arise, whether any such company would have power to lease space in such subway, unless the same were to be implied from the provisions of said laws of 1884 and 1885, or from its general powers conferred by law or implied therefrom. But as no such company has availed itself of the provisions of those laws, it is necessary to inquire if there is any legal authority in this state by which a company could properly act as agent for the board in building such subways, and in maintaining, operating and leasing the same hereafter.

By chapter 425 of the laws of 1862, it is provided that any telegraph company in this state may construct, own, use and maintain any line of telegraph not described in their original certificate of organization, and may join with any other corporation in constructing, leasing, owning, using or maintaining such lines.

And by chapter 397, laws 1879, as amended by chapter 483, laws 1881, it is provided that any telegraph company is authorized to construct lines of electrical conductors underground in any city, village or town in this state, subject to the provisions of the law governing such companies, provided it first obtains the consent of such cities, etc.

It would seem that the provision of these acts, read together with those of the laws of 1884 and 1885, would be sufficient to enable a telegraph company in this state to build, own, operate and maintain subways for electrical conductors; and as the right to lease is a right incidental to ownership, it would seem that telegraph companies owning such subways would have power to lease those parts of them not necessary for its own business. This principle is acted upon and frequently practiced in this state, as many telegraph companies are in the habit of permitting, telephone, electric light and district messenger service companies to string wires upon their telegraph poles for hire.

By chapter 611, laws of 1875, it is provided that "Corporations may be organized under the provisions of this act, for the carrying on of any lawful business except banking, insurance, the construction and operation of railroads, or aiding in the construction thereof, and the business of savings banks, trust companies, or corporations intended to derive profit from the loan or use of money, or safe deposit companies, including the renting of safes in burglar and fire-proof vaults."

There can be little question but that a company organized under this law, with proper provisions duly stated in its articles of incorporation, would have full power to build, maintain and operate a subway such as is contemplated in the acts above referred to, and to lease space therein.

In order to create such a company, five (5) or more persons, a majority of whom shall be citizens, residents of this state, must make a certificate, signed by each of them, duly acknowledged and setting forth:

1. The name of the proposed corporation.
2. The object for which it is to be formed, including the nature and locality of its business.
3. The amount of subscription and the capital stock.
4. The number of shares of which such capital stock shall consist.
5. The location of the principal business office.
6. The duration of the corporation, which shall not exceed 50 years.

This certificate is filed with the secretary of state, who issues a license to the persons signing the certificate, empowering them to receive subscriptions. When one-half of the capital stock has been subscribed for and 10 per cent. paid in, the subscribers may meet and organize; upon filing a verified record of the proceedings of such meeting with the secretary of state, he issues a certificate of corporation, a copy of which is filed with the clerk of the county where the principal business office of the corporation is situated. Such company may be either limited or unlimited liability of stockholders.

It would thus appear that a corporation can be created under the laws of this state with power to build, maintain and operate a subway of electrical conductors, and to lease space therein.

A corporation is impliedly authorized to borrow money, and has the incidental power to give security for its repayment.

And this power has been repeatedly exercised by telegraph companies in this state without question.

It would thus appear that the money required for the building of the subway by a telegraph company may be legally raised by its bonds secured by mortgage. This power, also, is possessed by companies organized as above suggested, but in such cases they are restricted by the said act of 1875, section 13, which provides that the amount of bonds outstanding at any single time shall not exceed one-half of the corporate property of such corporation.

By section 6 of the act of 1885, the term of office of the commission expires on November 1, 1887. It would appear to be pertinent for the commission to make a contract with the company building such subway by which the supervisory control thereof should remain with the commissioners during the remainder of their term of office, and with successors having power to exercise such control as the parties should agree.

II.

We now come to that part of the commission's resolution which speaks of "necessary legal precautions and safeguards in the government of such company."

In a general way it may be said that there are four parties in interest in this matter:

(1). The people.
(2). The commission.
(3). The companies operating electrical conductors.
(4). The company which will act as agent for the commission in carrying out the will of the people.

The interest of the first named—the people—is plainly indicated in the act and identical with the duty and interest of the commission, viz.:

That the wires shall be placed underground—speedily, safely, without expense to the people or the commission—without deteriorating from the efficiency of the electrical service as it is at present.

The interest of the companies is bounded by the cost and trouble of changing from an overhead to an underground system, of maintenance when so changed, in securing such facilities as they may need on fair and impartial terms, and in being guaranteed against interference with their conductors and the impairment of their efficiency.

The interest of the constructing company is in securing a fair return for the investment made in carrying out the plan of the commission for the laying, operating and maintaining the subway.

It may safely be said that if the commissioners can provide satisfactorily for

1st. The proper laying of the subway,
2d. The proper allotment of spaces within it,
3d. The proper adjustment of rentals,
4th. The proper supervision of wires and freedom from interference,
5th. The proper protection from law suits,
6th. The proper security for carrying out the agreement, and
7th. The proper adjustment of disputes,

they will amply protect the rights and interests of the people, the electric companies, and themselves, while all other points, such as the cost of the subway to the company and the government of the company in its own affairs not conflicting with the points noted, may be left to the company itself for its own protection.

It does not make the slightest difference to the public or the electric companies or the commission who the constructing parties are, provided their security is ample—nor how much the subway costs, provided it is laid satisfactorily and honestly—nor how much the company makes on its investment, provided the charges are properly regulated and reasonable—nor where it buys material, provided the material bought is up to the standard, and the city and commission are protected from responsibility—nor how much space is rented to any company using electrical conductors, provided every other such company can get what space it desires—nor how often or much one company changes or repairs its wires, provided it does not, in so doing, interfere with the wires of some other company.

The commission in adopting a general plan for laying the subway, have adopted, with excellent reason, the principle of retaining in their own hands the power to adjust the details of their plan to the circumstances of cases which will arise as the work is going on; and following their example, I have considered that the most satisfactory provision which could be made for disposing of the important questions arising in the relations between the commission and the construction company and the electric companies, would be to leave in the hands of the commission and their successors such power of moderation and adjustment as will make it clearly impossible for any action to be taken by the construction company unfair to the companies or to the people.

In the matter of constructing the subway, the plan of contract I have prepared provides distinctly that it shall be done in accordance with the plans and specifications furnished by the commission, and this extends to every detail, and provides for every change of plan the commission deem advisable. It will, therefore, still pertain to the commission to see that the subway is properly

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and honestly laid, and if it is not the supervising authority will be responsible.

In the matter of allotment of spaces, the contract distinctly provides against partiality or monopoly.

In the matter of rentals, the contract provides that they shall be subject to revision by the commission, and so, without the connivance of the commission, no extortion is possible. And such rentals are not to be more than the cost of maintaining overhead wires, as it at present prevails.

In the matter of supervision of wires and freedom from interference, the contract provides amply and in a way that cannot be questioned.

In the matter of security from and responsibility for lawsuits, provision is also made, and it is further provided generally as to disputes between the construction and the electrical companies—as to the successors of the commission, if their term of office is allowed to expire, and as to all necessary points to be provided for.

Finally, although it is not in any way obligatory upon the commission to provide that the city shall receive any benefit from the subway, except that of having space provided for city wires, free of charge, and the spirit of the contract is rather that where the construction company would receive more than a fair profit on its investment, such excess should be either its own or inure to the companies by a reduction of the rate of rental. Still, in case unusual profit should accrue to the company in any year by reason of the rental not being so reduced, it is made part of the contract that the city, the electric companies and the construction company shall divide all excess over ten per cent. net on the capital invested by the construction copmany.

I submit herewith the form of contract called for, which has been submitted to the attorney-general for his official criticism, and which I am authorized to say he will officially approve if properly presented to him as from the commission.

Very respectfully.

DANIEL L. GIBBENS.

5 Exchange Court, July 13th, 1886.

GETTING READY FOR WORK.

MEETING OF THE NEW YORK SUBWAY COMMISSION, JULY 13th

The Electrical Subway Commissioners met at the house of commissioner Moss, No. 543 Madison avenue. The three commissioners were present with their counsel, D. L. Gibbens, and engineer Thomson.

The engineer presented a report as to the capacity of the conduit required, and also as to the general plan of burying the wires. They are to be laid some 18 inches underground, in a conduit of asphaltum, with the drawing-in-and-out system, with man- or hand-holes at every block.

The details of the system have not yet been fully determined. The commissioners adopted the following resolutions:

Resolved, That the reports made this day by the engineers and counsel of this commission be laid upon the table for reference in providing for the details of the plan of the commission as they are required to be provided for.

Resolved, That all currents of great intensity should be separated from all other currents, and that conductors of power and those used in arc lighting should be placed, wherever practical, in a conduit by themselves, subject to such regulations as may from time to time seem advisable to the commission.

Resolved, That currents of light intensity should be separated from all other currents, and that telegraph, telephone, ticker, messenger, and fire-call wires and all those of that class may, wherever practical, be placed together in the same conduit, subject to such regulations as may from time to time seem advisable to the commission.

Resolved, That incandscent lighting wires should be provided for separately from all other wires, and be placed, wherever practical, in a conduit by themselves, subject to such regulations as may from time to time seem advisable to the commission.

Resolved, That the commission hereby invite all companies and persons in the city of New York using electrical conductors to submit estimates of the number and kind of conductors they will respectively require in an underground system in the several streets and highways of the city, and as to all other matters relating to their respective service, to submit such practical suggestions as to the elaboration of the general plan of the commission, not at variance with said general plan, as they may desire to submit for the information and consideration of the commission; the same to be submitted within 10 days from the receipt by said companies of copies of this resolution, which the secretary is hereby requested and directed to communicate to them without delay.

Resolved, That the plan of contract submitted to the commission for their approval by the counsel of the commission, and which their counsel has advised them will be approved by the attorney-general of the state, be, and the same is hereby made subject to such approval by the attorney-general. The contract which the commission is ready and desirous to make with any properly organized corporation which may be willing to sign said agreement to act as agent of the commission for the laying, maintaining, and operating of the subway.

Resolved, That, whereas, several propositions have been made and others will undoubtedly be made, to this commission by parties desirous of acting as agents of the commission in the performance of this work, and whereas it is proper for the commission to provide for a consideration of all such propositions, to the end that they may be informed as to which of the parties making such propositions is best able to carry out the said work, to furnish sufficient security for the carrying out of the proposed contract, all such propositions, together with all such as shall be made to the commission previous to their next meeting, shall be referred to the counsel of the commission, who shall report at said next meeting as to such proposals, and which of said proposals is in his opinion the best for the commission to accept with the reasons therefor.

Resolved, That the counsel of the commission be authorized to obtain the official approval of the attorney general of the contract submitted to the commission in the manner in which the attorney-general has signified his intention to so approve it.

Resolved, That the engineers of the commission be directed to continue their investigations of the manner in which the plans of the commission should be elaborated for each of the separate services and localities of the city, and to report such facts and data as they may collect from time to time generally.

Resolved, That the engineers of the commission be directed to submit to the commission as soon as possible accurate specifications proper to be furnished to such constructing company as may become the agent of the commission for the carrying out of the work of the length, size, capacity, etc., of an asphalt drawing-in and-out conduit to carry all the telephone, telegraph, etc., wires required in the localities and districts of the city where the commission have decided to begin the work of construction of subways, viz., from Twenty-third to Fifty-ninth streets, river to river, and also on One Hundred and Twenty-fifth street, from river to river.

The report which was presented by D. L. Gibbens, counsel to the commission, is accompanied by a form of contract to be made with the construction company which may secure the right to construct the conduit for the underground wires.

The form of contract prepared by Mr. Gibbens, to be signed by the commission and the officers of the construction company, provides that the company shall build and maintain the subways in accordance with the plans of the board, and shall have the management and rental of the spaces therein, subject at all times to revision, alteration, amendment, and reversal by the commission and its successors. Regular books shall be kept by the company, giving account of the amount of space rented in the subway, with the names of the persons renting it, the gross and net amount of rental paid for the space, and all expenditures and outlay of every kind, which books shall be at all times open to the inspection of the Board and its successors. The subways are to be constructed in accordance with plans and specifications furnished by the commission, and space must be leased to any authorized electrical company operating wires in this city which may apply for it, but no space not actually needed for its business shall be rented to any company to the exclusion or detriment of any other company needing space; and all space needed for the electrical conductors of the city and its departments shall be furnished free of charge.

The rent for the use of the subway to be collected from any company shall not exceed the present cost to the company of maintaining it conductors overhead, and rentals shall be at the same rate to all occupants. Whenever the net rentals, after paying all charges and expenses, shall exceed 10 per cent. of the value of the capital invested, the excess shall be paid one-third to the city, one-third to the companies occupying the subways, and one-third to the construction company. The companies are to own and manage their conductors, and in case of any dispute between them and the subway company, the commission is to be the final arbitrator. A bond of $500,000 is to be given by the construction company to secure the performance of the contract and to secure the commission and its successors against any patent or other suits arising from the building and maintaining of the subways. The bond is also to be a guarantee to the city for all damage by reason of the building of the subways, and against any injury to pavements or other property. If at any time the subway company fails in the performance of its duty under the contract, the commission reserves the right to take possession of the work and make such disposition of it as may be lawful.

The North American Telegraph and Electric Company, which was incorporated in Albany on Monday, has been formed to secure the work of building the electrical subways in this city, if possible, and failing in this, to prevent the company to which the commission may give the contract from infringing on any of the patents held by the new corporation. The incorporators are Henry Allen, Lewis May, W. D. Dowd, and W. H. Johnstone, of Philadelphia, who has spent so much time in the fruitless effort to induce the subway commission to adopt his iron system. Mr. Allen claims to own the Mackintosh patents, which, he insists, cover every form of working vaults, by means of which the connection of underground wires is made and repairs to the conductors effected. James Boys and S. S. Ely have also given notice to the commission that they control the Mackintosh patents, so that in case there is any infringement on these rights there is likely to be a triangular fight in the courts. Lewis May owns the Johnstone patents for "hand-holes," and if any infringement on this is attempted, the new company will promptly begin war. A number of other patent rights are controlled by the North American Telegraph and Electric Company, which proposes to make all the trouble possible unless it gets the work of constructing and managing the subways in this city, but the Mackintosh and Johnstone are the most important ones.

At the meeting held on July 22d, Mr. Lauterbach, on behalf of the Consolidated Electrical and Telegraph Subway Company, submitted the form of the bond to be entered into, which he said had been ratified by the board of directors of the company, and also the names of the following five gentlemen as sureties in $500,000 as required under the terms of the contract: Alfred Scully, president of the Ohio Southern Railroad Company; Aaron B. Cohn, president of the A. B. Cohn Company, of No. 197 Water street, and of the Bloom Remedy Company of No. 41 Platt street; David R. Paige, of the firm of Paige, Cary & Co., who is a brother-in-law of John Huntington, of Cleveland, Ohio, one of the principal owners of the Standard Oil Company; John D. Hoffmire, president of the Knickerbocker Steamboat Company, and a director in various banks and street railroad companies;

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and Clinton Beckwith, of the firm of Beckwith, Quackenbush & Co., contractors, of Washington, D. C. These names were very satisfactory to the commission, and the surety given was formally approved. The bondsmen, collectively, were said to be worth over $4,500,000.

Before provisionally signing the contract the counsel to the commission said that he felt called upon to ask the indulgence of the company for a few moments, so that he might, by direction of the commission, give his ideas and the ideas of the commissioners as to the exact construction to be put upon the various clauses of the contract. He was aware that very often the worst person to construe a contract was the party who drew it; nevertheless he desired, as much as possible, to avoid all trouble between the commission and the company, and the best way to serve this purpose was, in his opinion, for all parties to agree upon the exact meaning of the contract to be entered into. The document had been drawn with extreme carefulness. As he understood its provisions the company was to act as the servant of the commission at all times, in all things, and under all circumstances. There was to be no unfairness and no oppression, but there was to be fair play all round. The company was to build the conduits in accordance with the plans of the commission, and was to maintain them under rules and regulations to be adopted by the commission. No favoritism was to be shown to any company having overhead wires, and the conduits were to be open at the same rental to all like companies occupying relatively similar spaces. The rentals were to be fixed by the commission, and in no case were they to exceed the cost of maintaining the wires as at present, or 10 per cent. upon the capital invested in the work of constructing and maintaining the conduits.

In short, Mr. Gibbens said, the commission was to supervise and direct the work of the company at all times. On the other hand, the company was to be protected by the commission in the enjoyment of its contract, and the commissioners were to use all the power under the law to compel the various electrical companies to place their wires in the conduits of the contracting company. Mr. Fitzhugh and his fellow-directors took all the risk as to any flaws in the laws under which the commission had acted, and the commission was in no way bound to settle the legal status of any controversy that might arise between the contracting company and any telegraph, telephone, or electric light company. Mr. Gibbens, in conclusion, referred to the silence of the law in regard to the wires already underground. The commission assumed no responsibility to compel the placing of these wires in the conduits about to be constructed. These remarks of his, he thought, should be formally assented to by Mr. Lauterbach and Mr. Fitzhugh in behalf of the Consolidated Telegraph and Electrical Subway Company and its board of directors, so that in future there might be no possibility of mistake as to the exact meaning of the contract.

Mr. Lauterbach, who had taken a few notes of the remarks of Mr. Gibbens, said that the counsel for the commission had, in his judgment, presented the facts of the case in a very lucid manner. He had been accurate and truthful, and, if anything, had understated the meaning of certain clauses of the contract. The Consolidated company knew full well the weak points in the armor of the commission, and it knew that it was subservient in every way to the will, and perhaps the caprice, of the commissioners and their successors. Notwithstanding all the difficulties in the way, however, the company felt safe in giving bond for the performance of the work in $500,000, because the company knew that public opinion wanted the wires to be buried; public opinion demanded the removal of the dangerous and unsightly poles from the streets of the city, and public opinion would not rest satisfied until every wire in the city of New York was underground. The company that put the wires underground would be a benefactor to the city, and nobody would begrudge the investors in such a public-spirited enterprise a fair return on their investments. The talk about there being partiality by the commission or by the company in the use of the conduits was all bosh, for it would be to the interest of the company to bring every telegraph, telephone and electric light company into line. The only way any money could be made was by having the conduits used. Idle conduits would mean no dividends on the millions invested in constructing them He agreed thoroughly with Mr. Gibbens as to the construction of the contract, and thought that it spoke for itself most eloquently.

Although Mr Lauterbach's remarks were direct and straightforward, yet he did not formally accept Mr. Gibbens's statement for the consolidated company. The counsel for the commission noticed this omission, and, after whispering to Mr. Flower, asked Mr. Lauterbach this direct question:

"Are you authorized for your company to formally accept my statement as to what the subway commissioners and myself think this contract means?"

President Fitzhugh leaned over and spoke to Mr. Lauterbach.

"The president of the company represented by me," remarked the counsel, "says he agrees entirely with Mr. Gibbens's interpretation of the contract."

Mr. Gibbens even yet did not seem to be satisfied.

"Will you formally agree," he asked, addressing Mr. Lauterbach, "to have the remarks made by me brought before your board of directors at its next meeting and regularly acted upon?"

"I will do so with pleasure, sir," replied the suave Mr. Lauterbach; "but I can hardly conceive anybody as objecting to what you said."

This time Mr. Gibbens was satisfied.

"Mr. Lauterbach having agreed to the interpretation of the contract as understood by the commissioners," said he, "I will advise my clients, that pending the meeting of the board of directors of the consolidated company, the contract be provisionally signed by Mr. Moss, as secretary of the subway commission, and by Mr. Fitzhugh as president of the company."

Mr. Gibbens then laid the contract before Mr. Moss, who signed it, and then Mr. Fitzhugh attached his signature.

"Now the wires will go underground with a rush," said the Hon. Roswell P. Flower as he thumped the table before leaving.

Mr. W. J. Sefton, who has been the efficient secretary of the commission since its organization, has resigned the office, and his resignation was reluctantly accepted by the commissioners.

THE DORSETT COMPANY'S NEW YORK FACTORY.

The report of the New York Subway Commission in favor of asphaltum concrete as the most suitable material for subterranean electrical conduits is generally considered an endorsement of the Chicago system in which a conduit of this character is extensively used, manufactured by D. H. Dorsett, under his patents for material, machinery and certain details of construction. In devising a system for New York, however, Mr. John Thomson, mechanical engineer, acting in behalf of the commission has made several improvements upon the Chicago plan, which he deemed necessary in the organization of a system which would comply with existing conditions in this city.

The multitubular conduit, which is the basis of the system, is now familiar to all who are interested in subterranean work, and has been heretofore manufactured in Chicago for use in that, and other western cities. Believing that its success in the west would naturally lead to its introduction along the eastern seaboard, Mr. Dorsett decided last spring to establish a factory in New York city. A desirable piece of property was found at the foot of East 20th street, which has been leased from the Consolidated Gas Co. The building is of brick 66 feet by 200. In the rear is a yard 200 feet square fronting on the East river, with dock privileges, enabling shipments to be made by water if desirable.

In the south-east corner of the factory is the boiler room, containing two 80 h. p. boilers, one furnishing steam for power, the other for heating purposes. These may be used jointly or separately as required. Alongside the boilers is located the apparatus for drying sand, which consists of an inclined rotating cylinder, 3 feet in diameter, and 18 feet long. A separate furnace is used for this purpose, the flame and heat passing directly through the sand which is continually agitated, forming a miniature sand storm inside the cylinder as it revolves. After passing through this tube the sand is at once taken to the top of the factory by a bucket elevator, and carried to the different hoppers by a screw conveyer.

Adjoining the boiler room and separated from it by a brick partition is the engine room, where an 85 h. p. Corliss engine quietly performs its duty. The main floor of the factory is raised eight feet above the ground floor on which the engine and boilers are placed, thus affording room underneath for a line of shafting extending to the rear of the building, and supported by heavy framework. Upon the main floor are eight mixing pans, having steam jackets, into each of which a ton of material is placed at one time. The thorough stirring and mixing of the asphaltum, sand and chemicals is effected by means of heavy revolving rakes in each pan, driven by gearing from the main shaft below the floor. The mixture when at the proper temperature and consistency is fed by a pan containing the requisite amount of material. This pan is about three inches high, and is so constructed that the bottom can be withdrawn when directly over the mould. The material thus released drops into the mould in an even layer, and the tamp, having been previously elevated above the mould by automatic machinery, is again set in operation and continued until the charge is thoroughly compact. This operation is repeated until the top of the mould is reached, when the cores of steel are withdrawn into the basement by machinery.

When the section, three feet in length, is finished, it is lifted by a crane, swung around and lowered into a cooling tank where it is allowed to remain as long as it is necessary and when taken out the mould is removed. There are four of these tanks 9 feet long, 5 feet wide and 5 feet deep, sufficiently large to accommodate two of the largest size man-holes. They are kept constantly supplied with a flowing stream of cold salt water pumped from the river. The tanks are built of plank, and are lined with a layer of the conduit material to render them water tight.

The asphaltum is first heated in the melting pans designed for that purpose, of which there are four located on the attic floor above the machine room. These are steam jacketed, and the

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asphaltum is stirred in them by horizontally rotating rakes, driven by a second line of shafting on the upper floor. Here are also located eight sand bins or hoppers, corresponding with the mixing pans below, from which the sand is drawn as required. The full capacity of the factory will be about 3,600 feet per day of the six hole conduit, such as is now being made to apply on the Brooklyn contract. The man-holes as designed are 4 feet 6 inches long by 8 feet wide inside, and as deep as may be required, being built up of concrete molded in sections and cemented together with the same material. The top of the man-hole consists of a cast-iron collar 16 inches deep with inclined sides contracting to an opening on top, oval in shape, 3 feet 6 inches long by 2 feet in width. This is fitted with a cover 1½ inches thick, corrugated on top in the usual manner to prevent the slipping of horses. The cover is fastened down to the upper part of the collar by means of two bars running transversely inside, to which the cover is secured by two joint bolts, the heads of which are fitted with rubber washers. The top edge of the collar has a flattened surface, with a raised flange to provide a bearing and keep in place a rubber gasket, which when the cover is forced down upon it by the bolts prevents the ingress of surface water. These gaskets are manufactured in the form of a ring and are made hollow, similar to tubing, to insure thorough elasticity.

While the formula by which this conduit material is mixed is covered by patents, the exact manner of properly introducing the chemicals is a matter of experience, and elaborate tests made with suitable apparatus by direction of the commission proved conclusively that it greatly improves in strength by the lapse of time. Advantage has been taken of four years experience in manufacturing and laying this conduit in Chicago, to introduce various improvements in manufacturing, so that the New York factory is in every respect much more complete than the original establishment.

The Dorsett company have manufactured and laid in Chicago the following different forms of conduit: 10 duct, rectangular in form, with rounded corners; 7 and 19 ducts, round in cross section. They are now manufacturing and laying in Boooklyn conduits having 4, 6, 8 and 10 ducts. They claim that they can produce a conduit of almost any form and size, and from a careful inspection of their machinery and methods we have no reason to doubt but that their claim is a just one.

Although considerable time has elapsed since the New York commission set about devising a plan for use in this city, no time will be lost in preparing for the manufacture of the conduit, so it appears very probable that if the resources of the Dorsett factory are availed of at least a dozen miles may be put down before the 1st of December. It is very probable that the decision in favor of asphaltum concrete as a suitable material for conduits will lead to its adoption in other cities, in which case samples may soon be found as part of the stock of every well regulated electrical supply store.

MR. WESTON'S NEW LABORATORY.

Mr. Edward Weston, who, for a number of years past has been the electrician of the United States Electric Lighting Company, and has also had general charge of the extensive manufactory of that company, at Newark, New Jersey, has recently completed a handsome and substantial laboratory building, two stories in height, with an extensive area of floor surface, and well lighted on all sides. The structure is of brick with terra-cotta trimmings, and is situated in the rear of Mr. Weston's handsome residence on High street, Newark. The laboratory has been provided, among other things, with a complete outfit of machine tools, by the best makers, and a very fine Armington & Sims engine, for supplying power.

Mr. Weston's extensive and costly collection of apparatus for physical and electrical measurement, formerly contained in his laboratory at the factory, has been removed to the new building, and the place formerly occupied by it, will henceforth be utilized for manufacturing purposes and for the electrical tests and investigations necessary in carrying on the electric lighting business.

The contract heretofore existing between the United States company and Mr. Weston having expired by limitation, a new arrangement has been entered into, in pursuance of which Mr. Weston will hereafter act as the consulting electrician of the company, and will thus be left free to devote his time exclusively to various lines of original investigation, in some of which he has already distinguished himself. We have no doubt that the new arrangement will prove to be an advantageous and satisfactory one for both parties, for experience shows that after a certain point has been reached in the development of an extensive business, like that of electric lighting, more satisfactory results, both scientific and commercial, are often reached by separating the laboratory and the manufactory. With the splendid equipment and facilities now at his command, Mr. Weston, who is comparatively a young man, may be expected to achieve results which will surpass even the brilliant record which he has already made for himself. The vast field of electrical research is but just ripening for the harvest, and it would be rash to predict what may be brought about within a few years, by the labors of the keen-sighted, energetic and indefatigable corps of experimentalists, inventors and electrical mechanicians, of which Mr. Weston is easily one of the foremost members

THE WESTINGHOUSE ELECTRIC LIGHT AT TRENTON, N. J.

The Westinghouse Electric Company, of Pittsburg, Penn., which is one of the latest concerns to take up the business of incandescent electric lighting, has recently completed and put in operation a central station plant, under a contract with a local electric lighting company at Trenton, N. J. This installation, although not a very large one, in the excellence of its arrangement and the completeness of its appointments, is not excelled, if equalled, by anything of the kind in the country of which we have any knowledge. Many features of the system are new and distinctive, and we have considered them of sufficient interest to warrant us in preparing a detailed description with illustrations, which will appear in our next issue.

The boilers, engines and machinery were supplied by the firm of Westinghouse, Church, Kerr & Co., of Cortlandt street, New York, who are also agents of the Westinghouse Electric Company, and in that capacity also supplied and installed the dynamos, lamps and wires. The work has been done in a skillful and creditable manner, and the performance from the start has been excellent. The same parties have a number of other similar installations in progress.

DANGERS OF THE GREAT TOWER.

The iron tower which is to form the chief attraction of the Paris Exhibition of 1889, is already beginning to fill the Parisian mind with apprehension; and a *savant* explains in the *Moniteur* the curious phenomena which will be produced by this immense mass of iron rising to a height of 300 metres. He says that the enormous blocks of iron running north and south will become polarized, and that this polarization will soon invade the whole column. Then who knows whether the four lifts with their continual friction will not increase the magnetic influence a hundredfold? In this case all articles for a mile round will be attracted to the tower, and will adhere to it as a needle does to a magnet. If the troops quartered in the Ecole Militaire, hard by, be called out to drill, it will be all in vain for the commanding officer to shout "En avant!" if they are paraded with the column behind them; they will irresistibly be drawn to the rear, with the exception of the drummer, who does not carry a rifle. All the houses in Paris will suffer from a St. Vitus's dance, and, gradually attracted toward the Champ de Mars, will finally find themselves stuck to the tower. As for locomotives entering Paris, it will be found impossible to stop them at the various termini; they will rush through Paris and dash themselves to pieces against the centre of attraction. These and other evils we are told, will follow the erection of the great Eiffel tower; but then the *Moniteur* is opposed to the anniversary of the capture of the Bastille being observed, and may have exaggerated the consequences.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.

The Association of Railway Telegraph Superintendents met at St. Paul, June 16. President C. W. Hammond, of the Missouri Pacific, in the chair. The association discussed the character of dismissal and application blanks for employés, and best means of possible check, and useless telegraphing of railroad business, which matters were referred to committees. Nineteen new members were received. A committee was appointed to report at the next annual meeting some new signal for the cipher instead of the long dash. A. R. Smith, Chicago, Rock Island and Pacific, was elected president for the ensuing year. George L. Lense, of the New York and New England, was elected vice-president, and P. W. Drew, secretary and treasurer.

TELEPHONE TRIBULATIONS IN INDIANA.

The citizens of Evansville, Ind., do not appear to be any happier since the common council has taken down the lines of the Cumberland Telephone Co. At a large mass meeting recently held the following resolutions were adopted:

Resolved, That we, as citizens, in mass meeting assembled, do hereby denounce the action of the City Council, whereby the property of the Cumberland Telephone Co. was wantonly vandalized and destroyed, without authority of any court of law of this land.

Resolved, further, That the telephone subscribers' business interests have been outraged and damaged, and steps should be taken at once to recover damages for the vandalism committed July 8, 1886.

Resolved, further, That in view of repeated usurpations of power by the Common Council and their disregard of the rights and privileges of citizens, that a necessity has arisen for the employment of a committee of safety, whose duties shall embrace not only a surveillance of our public servants, but to closely watch all necessary local legislation.

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PROSPERITY OF CORNELL UNIVERSITY.

The report of President Adams, made to the board of trustees of the Cornell University, June 16th, indicates a condition of prosperity and success unequaled in the history of the institution. The number of students in attendance during the year has been 649—which is 40 more than in any previous year, and 75 more than last year. The nearest approach to the present number was in the academic year 1870–'71, when the number of undergraduates was 609. The senior candidates for the Bachelor's degree number 25 more than at the commencement one year ago. Steady progress has been made in perfecting the material equipment of the university. More than $20,000 have been spent in completing the appliances and accommodations of Sibley college. Several of the museums have been enlarged. Considerable additions have been made to the library, and the campus has been greatly beautified. In the memorial chapel has been placed a marble statue of Ezra Cornell. Henry W. Sage has placed at the east end of the Sage chapel a window in memory of his wife, who was thrown from her carriage and killed one year ago. The window was made after drawings by Millais, and is a beautiful one. Portraits of Hiram Sibley and Andrew D. White, both by Huntington, have been added to the paintings on the library walls.

ELECTIONS AND APPOINTMENTS.

At the annual meeting of the stockholders of the Bishop Gutta-Percha Co., held on the 7th inst., E. I. Anderson, of Chicago, and Samuel Boardman and H. E. Blitz, of New York, were elected trustees. The trustees elected Samuel Boardman president and treasurer, and appointed Henry A. Reed secretary and general manager.

Alexander P. Wright, the well-known electric light engineer and photometric expert, late with the U. S. Electric Lighting Co. at Newark, has accepted a similar position with the Westinghouse company.

Harry M. Byllesby, of Roselle, N. J., has been appointed acting manager of the Westinghouse Electric Co., and will have his headquarters at Pittsburg, Pa.

ELECTRIC LIGHT AND POWER.

The Van Depoele Electric Manufacturing Company has contracted to furnish the Winona (Minn.) Electric Light Company with a plant of 600 16 c. p. lamps, and a number of larger lamps.

The Jarvis Engineering Company, of Boston, recently furnished a steam plant to the Manchester Gas Company, Manchester, N. H., consisting of a 60 h. p. Armington and Sims engine, tubular boiler with Jarvis setting to burn coke screenings, Korting injectors, National heaters. The system to be used is the Thomson-Houston.

The Defiance (O.) Electric Light Company has filed articles of incorporation, with $15,000 capital. Their plant is from the Western Electric Company, Chicago.

The Royal Electric Light Company, Montreal, has been granted a five years' contract to light St. Catharine, St. Lawrence, Craig, Notre Dame, McGill and St. James streets of that city, in consideration of $24,000 per annum. The system to be used is the Thomson-Houston.

The City Electric Light Company, of Philadelphia and Camden, N. J., has been formed with $100,000 capital.

The Natick (Mass.) Electric Company has been formed, with $30,000 capital stock.

The Birmingham Electric Light Company, Birmingham, Ala., which was incorporated some time since, has begun work on the construction of their plant.

Nashua, N. H., is organizing an electric light company.

It is proposed to construct an electric railway from the south side to St. Clair township, passing through Knoxville, near Pittsburg, Pa.

The Westinghouse Illuminating Company, of Schenectady, N. Y., has been incorporated with $30,000 capital stock.

The city of Jacksonville, Ill., has contracted for a system of electric lighting, embracing six iron towers each 125 feet in height. These towers are to be in different parts of the city, and are to be erected by July 1. They will to a large extent supplant the present system of street gas lamps.

It is stated that the city of Warren, O., contemplates the erection of a system of electric lighting.

The Automatic Electric Light Company has been organized at Portland, Me., with $100,000 capital stock.

In connection with the festivities on the occasion of the recent royal marriage in Portugal, numerous nocturnal displays were made. Much interest was attracted by the electric lighting of the royal palace of Ajuda, carried out by Messrs Woodhouse & Rawson, of London.

On either side of the wide approach to the palace were fixed poles covered with crimson cloth and with gilt spear head tops, from which were suspended six powerful arc lamps, besides two suspended over the arcade at the entrance of the palace. Thanks to the elevated position which the palace enjoys, the lights were witnessed not only from the bar of the Tagus for several miles of its length, but also from the greater part of the city, and even from the villages of Cacilhas, Barriers, and the historic castle of Palmella, far up the river.

At the small town of Hernosand, in the north of Sweden, a small installation of 27 arc lamps has been established. The dynamo used is a Thomson-Houston, which is driven by a waterfall two miles from the town.

Engineering reports that the passage of the Suez Canal, which, until recently, occupied from thirty-six to forty-eight hours, can be made, now that navigation during the night is possible, in sixteen hours for mail steamers and war vessels, fitted with the electric light apparatus and projectors, provided by the Canal company. A complete plant is taken on board a steamer on entering the canal, and discharged on leaving it.

The Appleton Electric Street Railway Company, Appleton, Wis., is constructing a new line expressly adapted to the Van Depoele system. Cars are being specially constructed by the Pullman people for this road, and the entire plant will be especially well put up in every respect. Water power will be used to run the motors, and a large and convenient building is being constructed for the utilizing of that force through the medium of huge water wheels.

Among the new companies incorporated are the following: The Daft Electric Light and Power Company, East St. Louis, Ill. Capital stock, $300,000. John Scullin and others, incorporators.

The North Attleborough Steam and Electric Company, Attleboro', Mass. Capital stock, $20,000. George A. Hancock and others, incorporators.

The Thomson-Houston Electric Light Company, Detroit, Mich. Capital Stock, $100,000. John H. Hapgood and others, incorporators.

MANUFACTURING AND TRADE NOTES.

A new form of the Davey motor is being brought out by C. P. Willard & Co., in which the engine is detached from the generator. It is arranged to take steam from a radiator or from the main boiler of a building, and is intended for pumping and running a small electric plant, ventilating and similar service.

MISCELLANEOUS.

The International Society of Electricians have determined to build in Paris, laboratories for the use of physicists. The nucleus of the foundation fund is supplied by the surplus from the last electrical exhibition, which amounts to 360,000 francs.

PERSONAL MENTION.

Friends of Mr. T. A. Edison who read the New York *World* of Saturday, July 24, were shocked to see his portrait surmounted by the head line "DROPPED FROM THE BRIDGE." The *World* should be more careful of its portraits of celebrities. Something less striking than Mr. Edison's features would have served for a picture of the scapegrace who jumped from the East River bridge.

Professor H. S. Carhart has accepted the Chair of Physics in the state university at Ann Arbor, Mich., having been unanimously elected to the position He will be followed to his new field of work by the best wishes of his friends and of all who are acquainted with his scholarly reputation. The North Western University and his many friends will regret to lose him from their scientific and social circles.

THE TELEPHONE.

The New York and Pennsylvania Telephone Co. are in trouble with the common council of Elmira, N. Y. The council claims more free service for the city than the telephone company is disposed to accord, and threaten to compel the removal of pole lines and the substitution of underground wires.

SUBMARINE CABLES.

In the submarine cable laid last year between Mozambique and Zanzibar, the insulated core was protected by brass tape. This forms a complete protection against the teredo which destroys the insulation of the cable. This type of cable is being much used where the teredo is found. Copper tape was used for some submarine cables many years ago, but not for the protection of the insulator. Its application for that purpose is recent, although the plan was patented nearly 20 years ago. Copper tape is also used for protection against land insects in some places where underground wires are necessary, all other methods to protect the insulation having proved ineffectual.

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Conducted by F. L. POPE. G. M. PHELPS, JR., R. W. POPE, } Associate Editors.

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NEW YORK, SEPTEMBER, 1886.

GOOD AND CHEAP LIGHT.

THE rivalry between the gas interests and the promoters of electric lighting seems to be rather intense just now, and the public is in a fair way of being well served by either or both. Great activity prevails among the electric light people in extending their business, both by installations in new fields, and by rapidly increasing development of fields already occupied. They are constantly improving the quality of their service. Much attention is also given to the improvement and cheapening of gas light, through new methods of making the gas, as well as improved lamps or burners. Indications of a possible introduction of electric lighting in some localities have induced unwonted activity on the part of the local gas companies in bettering their service.

We are led to consider the situation by the reports of the recent contest at Cincinnati between the electric light promoters and the gas company, in which Gen. Hickenlooper, president of the gas company, took so prominent a part, making a savage attack upon electric lighting generally.

By producing before the city council the results of a diligent search for the practical and commercial failures of electric lighting, Gen. Hickenlooper made an apparently strong case against licensing the new enterprise. The effect of his attack was augmented by his seeming success in showing a speculative motive on the part of the electric light promoters at Cincinnati. Had the general been hunting for the *successes*—practical and commercial—of electric lighting, he could have filled his bag with far less beating of the bushes. The present activity in the organization of local electric lighting companies, and the crowding of the facilities of manufacturers to the utmost in keeping abreast of orders, testify sufficiently to the rapid growth of the business. Some of the gas journals have made much of the Cincinnati affair. The force of their remarks against electric lighting is somewhat weakened by the presence in their neighboring news columns of announcements that several gas light companies are about to establish electric light plants.

Much has been gained in the interest of electric lighting during the past two or three years by the general adoption of more rational and conservative methods of exploiting the business than those prevailing earlier. There is very general recognition of the fact that while the business does not offer abnormal opportunities of gain, it does afford a large field for the employment of capital and skill judiciously invested and applied.

At present there is apparently not sufficient control of fundamental features of arc or incandescent lamps, or of dynamos, by virtue of patented inventions, in the hands of any single interest or combination, to justify any material taxation of the business of lighting, in the way of royalty. Local lighting companies, organized under recent and present conditions, are therefore not handicapped by large contributions of their capital stock exacted by the "parent" company from which they purchase their plant. They are thus relieved from a burden that has, in many cases, proved very onerous to the business in the past; and are in much better position to serve the public well, and make some adequate return on their investments, than many of their predecessors. Manufacturers of electric lighting machinery and apparatus have now to rely for business less upon control through patented invention than upon the specific excellence and reasonable prices of their products. In this regard their business is rapidly assuming the character of manufacturing industry in general. The best goods for the money make their way.

A further great gain in the practical and commercial efficiency of the business of electric lighting has been achieved through the much greater care and thoroughness now practiced in the design and construction of plants than was formerly deemed requisite. Practical and financial failure has many times been due to inadequate provision and slovenly construction of outfit. Badly adapted power plant has been a conspicuous cause of failure. Purely electrical factors have cut the least figure in such failures as have occurred. The dynamos and lamps of reputable manufacturers can be depended upon to do good service. Experience has shown that every part of a projected plant must be carefully considered; the size of conductors, the materials and the methods of line construction, the arrangement of central station, the provision of adequate and trustworthy motive power. Knowledge and training are being brought to bear more and more upon these points, and many plants are models of engineering work.

Systems of current distribution are engaging the attention of many electric light engineers. Much has already been accomplished in extending the range of territory that can be economically supplied from a central station, and a much further advance in the same direction is assured by the early introduction of the "regenerator" or "transformen" system of distribution. It is already practicable to cover sufficient ground with incandescent systems to supply light for domestic purposes, not only in cities, but

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in country towns, at rates that put the gas companies on their mettle. The testimony of prominent scientific and practical witnesses in the parliamentary investigation in England, looking to some modification of the oppressive legislation in force regulating the establishment of electric lighting, is nearly all to the effect that the opening of a fair field in competition with gas interests will lead to large and rapid introduction of electric lighting, that capitalists are held off only by the onerous conditions attached to franchises granted under existing statutes; conditions compelling the surrender of plant and business at the option of local authorities, at net cost, after twenty-one years. There seems every reason to expect a rational and just revision of the government regulations of the business in England, and on its accomplishment we may look for a marked increase there in central station lighting. There is no doubt that electric lighting is firmly established in public favor, and that it has reached a sound commercial basis. Between it and gas there would seem to be no reason why people should not get all the light they want, good, and at reasonable cost.

DEFECTIVE INSULATION IN ARMATURES.

In reading the initial portion of the report of M. Maurice Levy on the experiments in the electric transmission of power between Creil and Paris, conducted by M. Marcel Deprez, attention is at once arrested by the early failures due to imperfect construction of the generating dynamo used at Creil. The defects are fully set forth by M. Levy, as well as the remedies applied. We quote:—

The generator at Creil, like the recipient at Paris, required two Gramme rings, mounted on the same axle, and connected in series.

In the Gramme machines the core of soft iron upon which the circuit of the ring is coiled is most frequently of iron wires.

M. Marcel Deprez prefers to adopt round plates of thin sheet-iron, insulated from each other by means of paraffined paper.

In the first rings manufactured these discs were certainly insulated in this manner, but imperfectly. As for the connecting rods which traversed all these discs they had been merely covered with a layer of shellac varnish, which was sufficient electrically but not mechanically; the varnish was broken whilst the rods were being driven in. Thus, in the first attempts there were produced, in the entire mass of the iron, powerful Foucault currents, which absorbed almost the entire motive force. The yield was almost nil.

First reparation of the rings of the generator.—It was then determined to make new rings with cores of iron wire. The yield was then better. But as it had been thought sufficient to coat the wires with two layers of silk and one of cotton without the whole being saturated with gum-lac, and, as further, the wrapping of the wires had not been carried out so as to avoid great differences of potential between adjacent wires, frequent damage took place.

These are the rings which were in action on the visit of the Academy of Sciences, December 5th last.

This day squally weather had, as it is known, entangled the wire of the line with the telegraph wires. There resulted discharges which were felt at La Chapelle and at the telegraph office of the artillery at Saint Denis, where two instruments were burnt. The rings were rendered useless, and the experiment was forcibly interrupted.

Final reparation of the rings of theg enerator.—In consequence of this incident, M. Deprez decided to reconstruct his rings afresh, returning this time to his first idea of forming the cores and discs of sheet-iron, but taking care to enclose each connecting rod in a tube of hardened caoutchouc.

At the same time the diameters of the rings designed at first as of 1.40 metre, were reduced to 0.78 metre, and the pre-arranged speed of 400 revolutions was prudently reduced to 200.

The bobbins were made in segments, each occupying one-seventh of the circumference, and wrapped with layers of a single continuous wire, so that only wires slightly differing in potential could come in contact.

On the other hand, for convenience in manufacture the sheet-iron cores were no longer made each of a single piece, but of two segments, one of which occupies six-sevenths of the circumference, and leaves, consequently, a gap equal to one-seventh, by which means six of the seven bobbins forming wrapping of the ring can be strung as beads are strung on a necklace.

Thus the sixth-sevenths of the ring are formed. The last seventh is placed entirely with its core, like the keystone of an arch.

These arrangements have, from an industrial point of view, the precious advantage of not merely simplifying the first manufacture of the rings and of rendering them very strong and enduring, but also of permitting the quick repair of any damage or injury which may occur.

If a wire happens to be burnt it is sufficient to replace the segment of which it forms a part, and as the segments are all alike, a certain number are made beforehand, forming exchange pieces which may be introduced without difficulty and without having to re-make the entire ring.

With the introduction of these various improvements the epoch of fruitless trials and of incessantly recurring accidents came to an end, and there followed the epoch of prudent, slow, but certain advance.

If there be any American makers of dynamos not yet sufficiently impressed with the necessity of the most thorough insulation in armatures, the above extract may be of use to them. The infrequency of burned-out armatures now-a-days, indicates a general observance of proper precaution in their manufacture. Probably more interruptions of service were due to inadequate care in this regard, in the earlier days of electric lighting, and other uses of dynamos, than to any other cause.

WHEN WILL THE WIRES BE BURIED?

No pavements have been taken up at this writing, although a date for beginning work has several times been appointed and passed by. Monday, August 30th, is now assigned for the commencement of digging on Sixth avenue. The putting of the electric wires underground in New York city, does not appear to be so important a matter after all. Even the particular plan adopted seems to be a trifling affair compared with the overshadowing question of who is to be financially benefited by the new order of things. After a year spent in considering how the work was to be done, and when just on the eve of breaking ground, it is asserted that the whole business is a fraud; that the act creating the commission is unconstitutional, and the dangers overhead really appear trivial compared with the underground commotion. All of the arguments which have been so ineffectually brought to bear against the enforcement of underground legislation have been revived, and are now doing service in the hands of rival subterranean interests. The melon is scarcely large enough to furnish a slice for the promoters of each system.

Various newspaper attacks are made upon the organization of the Consolidated company—contractors for the construction and management of the subways—alleging some unholy participation in its control on the part of the Metropolitan Telephone Company and of Maurice B. Flynn. There seems to be some mystery as to the real composition and resources of the company.

Injunctions of the work are threatened by the owners of patents alleged to be infringed by the commissioners' plans, while the New York Electric Lines Company are attacking in court the constitutionality of the act creating the subway commission, and demanding for themselves the right to open the streets and lay their conduits and conductors, under a license granted them by the board of aldermen before the creation of the commission. Of course, all this litigation and criticism causes delay, and the actual

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work of construction cannot, under the most favorable auspices, make much progress before frost comes. The mere privilege of constructing and owning a system of subterranean conduits is of rather questionable value, unless the privilege of enforcing their use is conferred upon its proprietors. The attitude of the owners of overhead wires is decidedly adverse to such enterprise. The tendency of all the legislation has been in the interest of a monopoly. The great question to be decided is, who shall, control the monopoly after it has been fairly brought into existence. This trust is supposed to abide with the subway commission, and when its existence terminates by law, the monopoly may be perpetuated, by virtue of its actual possession of the ground.

President Flower, of the commission, seems undaunted, however, and determined to have the work go forward. The recent ejection of R. M. Squire from the office of commissioner of public works, and the appointment of Gen. Newton in his stead, together with the indictment of Squire and that of his partner in public plunder, Flynn, will relieve some well-founded apprehension of jobbery in the subway work on the part of city officials and the Flynn gang of contractors.

We hope to be able in our next issue to record some substantial progress in the actual work of laying conduits.

A MODEL APPOINTMENT.

By the selection of Gen. Newton for the office of commissioner of public works of the City of New York, Mayor Grace has done one of those particularly felicitous things that satisfy completely the sense of fitness. It is difficult to imagine a better appointment. Capacity, knowledge, training and character, such as befit the office controlling the engineering work of a great city, are all to be found in full measure in General Newton.

Notwithstanding the mayor's obvious efforts to do the best that unfavorable conditions permit in his appointments, this one is so ideally satisfactory as to have been somewhat of a surprise ; so accustomed has the public become to the apparent impossibility of getting fit men into municipal office in this city.

Jobbers and all speculators upon public apathy in the matter of city expenditures will now have to face a new order of things.

The general has undertaken the largest kind of a job, but we have no doubt of his capacity and courage to face and accomplish it. He has had an extended experience in the conduct of civil engineering operations on a large scale, involving the employment of large bodies of workmen and laborers, and has afforded a conspicuous example of the competency, thoroughness and honesty that characterize the work of army officers generally.

His appointment to so important an office, in the commercial and industrial capital of the country, where business methods in the conduct of public business have made the slowest advance, will give much encouragement and support to the cause of civil service reform throughout the country. The New York Public Works Department has been perhaps the greatest stronghold of political spoilsmen.

The appointment of General Newton will, it is fair to assume, constitute a final victory for the principles of business-like management in the department. The alleged control of the city's most important expenditures by Flynn and Squire was so grotesque that the public seems hardly to have considered it seriously until the recent exposures were made. The memory of the Tweed rings' downfall fifteen years ago had become generally somewhat vague, and many who kept it fresh probably indulged the fallacious theory that one such overthrow of plunderers would be effective for all time, and that however rapacious city officials might be, they would be permanently deterred from robbery by contemplation of the ruin that befel Tweed and his partners. It is now seen that no dependence can be placed in political appointments to positions requiring business fidelity in administration. It is in General Newton's entire freedom from party politics, as well as in his notable fitness for his new position, that assurance of permanent reform is to be found.

The municipal public work, including electric subways, will be executed and controlled with a view solely to efficiency and economy at last.

ECHOES OF TELEPHONE CONTENTION.

Efforts are renewed to excite some public interest in the Pan-Electric and other attacks upon the American Bell Telephone Company. Accounts of important discoveries in the patent office, to the advantage of the Gray interests, are telegraphed to the daily press by Washington correspondents. As they seem so far merely rumors, lacking any definite confirmation, they attract little general attention. Meantime the quarrel between Rogers and the Pan-Electric promoters develops an occasional new stage, more to the entertainment than the edification of the public.

Our Boston letter gives a report of recent output of telephones by the Bell company, showing a net gain of 8,872 in the period from December 21st to July 20th last, as compared with the same period last year. This is a very satisfactory exhibit, particularly in view of the unfavorable conditions in Indiana and other sections of the country.

As we go to press, Detroit is making ready for the Electric Light Convention about to assemble, and delegates are journeying thither from all parts of the country. The association has made much progress since its organization in bringing together representatives of the various interests of electric lighting ; and will doubtless become more and more a useful society for the periodical exchange of information and views of value to its members, and to all connected with electric lighting, as manufacturers, managers, or investors. In our next issue we shall publish a full account of the proceedings at Detroit.

The stay of execution on the $240,000 verdict against the Western Union Telegraph Co., the discontinuance of rumors of negotiations for consolidation of Western Union and Baltimore and Ohio interests, and the lull in the stock-reporting contest, have made the past month quieter than of late in news of the telegraph.

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ARTICLES.

THE PHYSICAL LABORATORY IN MODERN EDUCATION.[1]

From the moment we are born into this world down to the day when we leave it, we are called upon every moment to exercise our judgment with respect to matters pertaining to our welfare. While nature has supplied us with instincts which take the place of reason in our infancy, and which form the basis of action in very many persons through life, yet, more and more as the world progresses and as we depart from the age of childhood, we are forced to discriminate between right and wrong, between truth and falsehood. No longer can we shelter ourselves behind those in authority over us, but we must come to the front and each one decide for himself what to believe and how to act in the daily routine and the emergencies of life. This is not given to us as a duty which we can neglect, if we please, but it is that which every man or woman, consciously or unconsciously, must go through with.

Most persons cut this gordian knot, which they cannot untangle, by accepting the opinions which have been taught them and which appear correct to their particular circle of friends and associates: others take the opposite extreme and, with intellectual arrogance, seek to build up their opinions and beliefs from the very foundation, individually and alone, without help from others. Intermediate between these two extremes comes the man with full respect for the opinions of those around him, and yet with such discrimination that he sees a chance of error in all and most of all in himself. He has a longing for the truth and is willing to test himself, to test others and to test nature until he finds it. He has the courage of his opinions when thus carefully formed and is then, but not till then, willing to stand before the world and proclaim what he considers the truth. Like Galileo and Copernicus he inaugurates a new era in science, or like Luther, in the religious belief of mankind. He neither shrinks within himself at the thought of having an opinion of his own, nor yet believes it to be the only one worth considering in the world; he is neither crushed with intellectual humility, nor yet exalted with intellectual pride; he sees that the problems of nature and society can be solved, and yet he knows that this can only come about by the combined intellect of the world acting through ages of time and that he, though his intellect were that of Newton, can, at best, do very little toward it. Knowing this he seeks all the aids in his power to ascertain the truth and if he, through either ambition or love of truth, wishes to impress his opinions on the world, he first takes care to have them correct. Above all he is willing to abstain from having opinions on subjects of which he knows nothing.

It is the province of modern education to form such a mind while at the same time giving to it enough knowledge to have a broad outlook over the world of science, art and letters. Time will not permit me to discuss the subject of education in general, and, indeed, I would be transgressing the principles above laid down if I should attempt it. I shall only call attention at this present time to the place of the laboratory in modern education. I have often had a great desire to know the state of mind of the more eminent of mankind before modern science changed the world to its present condition and exercised its influence on all departments of knowledge and speculation. But I have failed to picture to myself clearly such a mind while, at the same time, the study of human nature, as it exists at present, shows me much that I suppose to be in common with it. As far as I can see, the unscientific mind differs from the scientific in this, that it is willing to accept and make statements of which it has no clear conception to begin with and of whose truth it is not assured. It is an irresponsible state of mind without clearness of conception, where the connection between the thought and its object is of the vaguest description. It is the state of mind where opinions are given and accepted without ever being subjected to rigid tests, and it may have some connection with that state of mind where everything has a personal aspect and we are guided by feelings rather than reason.

When, by education, we attempt to correct these faults it is necessary that we have some standard of absolute truth: that we bring the mind in direct contact with it and let it be convinced of its errors again and again. We may state, like the philosophers who lived before Galileo, that large bodies fall faster than small ones, but when we see them strike the ground together we know that our previous opinion was false and we learn that even the intellect of an Aristotle may be mistaken. Thus we are taught care in the formation of our opinions and find that the unguided human mind goes astray almost without fail. We must correct it constantly and convince it of error over and over again until it discovers the proper method of reasoning, which will surely accord with the truth in whatever conclusions it may reach. There is, however, danger in this process that the mind may become over cautious and thus present a weakness when brought in contact with an unscrupulous person who cares little for truth and a great deal for effect. But if we believe in the maxim that truth will prevail and consider it the duty of all educated men to aid its progress, the kind of mind which I describe is the proper one to foster by education. Let the student be brought face to face with nature: let him exercise his reason with respect to the simplest physical phenomenon and then, in the laboratory, put his opinions to the test; the result is invariably humility, for he finds that nature has laws which must be discovered by labor and toil and not by wild flights of the imagination and scintillations of so-called genius.

Those who have studied the present state of education in the schools and colleges tell us that most subjects, including the sciences, are taught as an exercise to the memory. I myself have witnessed the melancholy sight in a fashionable school for young ladies of those who were born to be intellectual beings reciting page after page from memory, without any effort being made to discover whether they understood the subject or not. There are even many schools, so-called, where the subject of physics or natural philosophy itself is taught, without even a class experiment to illustrate the subject and connect the words with ideas. Words, mere words are taught and a state of mind far different from that above described is produced. If one were required to find a system of education which would the most surely and certainly disgust the student with any subject, I can conceive of none which would do this more quickly than this method, where he is forced to learn what he does not understand. It is said of the great Faraday that he never could understand any scientific experiment thoroughly until he had not only seen it performed by others, but had performed it himself. Shall we then expect children and youth to do what Faraday could not do? A thousand times better never teach the subject at all.

Tastes differ, but we may safely say that every subject of study which is thoroughly understood is a pleasure to the student. The healthy mind as well as the healthy body craves exercise, and the school room or the lecture room should be a source of positive enjoyment to those who enter it. Above all, the study of nature, from the magnificent universe, across which light itself, at the rate of 186,000 miles per second, cannot go in less than hundreds of years, down to the atom of which millions are required to build up the smallest microscopic object, should be the most interesting subject brought to the notice of the student.

Some are born blind to the beauties of the world around them, some have their tastes better developed in other

1. Address delivered at the tenth anniversary of the Johns Hopkins University.

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directions, and some have minds incapable of ever understanding the simplest natural phenomenon; but there is also a large class of students who have at least ordinary powers and ordinary tastes for scientific pursuits: to train the powers of observation and classification let them study natural history, not only from books, but from prepared specimens or directly from nature: to give care in experiment and convince them that nature forgives no error, let them enter the chemical laboratory: to train them in exact and logical powers of reasoning, let them study mathematics: but to combine all this training in one and exhibit to their minds the most perfect and systematic method of discovering the exact laws of nature, let them study physics and astronomy, where observation, common sense, and mathematics go hand in hand. The object of education is not only to produce a man who *knows*, but one who *does;* who makes his mark in the struggle of life and succeeds well in whatever he undertakes: who can solve the problems of nature and of humanity as they arise and who, when he knows he is right, can boldly convince the world of the fact. Men of action are needed as well as men of thought.

There is no doubt in my mind that this is the point in which much of our modern education fails. Why is it? I answer that the memory alone is trained and the reason and judgment are used merely to refer matters to some authority who is considered final, and worse than all they are not trained to apply their knowledge constantly. To produce men of action they must be trained in action. If the languages be studied, they must be made to translate from one language to the other until they have perfect facility in the process. If mathematics be studied, they must work problems, more problems, and problems again, until they have the use of what they know. If they study the sciences, they must enter the laboratory and stand face to face with nature; they must learn to test their knowledge constantly and thus see for themselves the sad results of vague speculation; they must learn by direct experiment that there is such a thing in the world as truth and that their own mind is most liable to error. They must try experiment after experiment and work problem after problem until they become men of action and not of theory.

This, then, is the use of the laboratory in general education, to train the mind in right modes of thought by constantly bringing it in contact with absolute truth and to give it a pleasant and profitable method of exercise which will call all its powers of reason and imagination into play. Its use in the special training of scientists needs no remark, for it is well known that it is absolutely essential. The only question is whether the education of specialists in science is worth undertaking at all, and of these I have only to consider natural philosophers or physicists. I might point to the world around me, to the steam engine, to labor-saving machinery, to the telegraph, to all those inventions which make the present age the "age of electricity" and let that be my answer. Nobody could gainsay that the answer would be complete for all are benefited by these applications of science, and he would be considered absurd who did not recognize their value. These follow in the train of physics but they are not physics; the cultivation of physics brings them and always will bring them, for the selfishness of mankind can always be relied upon to turn all things to profit. But in the education pertaining to a university we look for other results. The special physicist trained there must be taught to cultivate his science for its own sake. He must go forth into the world with enthusiasm for it and try to draw others into an appreciation of it, doing his part to convince the world that the study of nature is one of the most noble of pursuits, that there are other things worthy of the attention of mankind besides the pursuit of wealth. He must push forward and do what he can, according to his ability, to further the progress of his science.

Thus does the university, from its physical laboratory, send forth into the world the trained physicist to advance his science and to carry to other colleges and technical schools his enthusiasm and knowledge. Thus the whole country is educated in the subject and others are taught to devote their lives to its pursuit, while some make the applications to the ordinary pursuits of life that are appreciated by all.

But for myself I value in a scientific mind most of all that love of truth, that care in its pursuit and that humility of mind which makes the possibility of error always present more than any other quality. This is the mind which has built up modern science to its present perfection, which has laid one stone upon the other with such care that it to-day offers to the world the most complete monument to human reason. This is the mind which is destined to govern the world in the future and to solve problems pertaining to politics and humanity as well as to inanimate nature.

It is the only mind which appreciates the imperfections of the human reason and is thus careful to guard against them. It is the only mind that values the truth as it should be valued and ignores all personal feeling in its pursuit. And this is the mind the physical laboratory is built to cultivate.

RELATIVE MERITS OF IRON AND STEEL WIRE FOR TELEGRAPH LINES.[1]

BY W. H. PREECE, F. R. S., M. INST., C. E.

Electrician to the General Post-office.

COPPER is gradually replacing iron for aerial telegraphs, owing to its greater durability in the atmosphere; but its greater cost has led to the use of smaller sized wires. This can be done without detriment to the economy of the line, for the resistance of copper, as compared with iron, varies very nearly inversely as its price per ton, and hence the cost per mile remains about the same. Hitherto only short lengths have been erected in smoky towns and through districts where chemical industries filled the air with gases destructive to iron wires; but the post-office telegraph department has recently erected a No. 14 copper wire, .080 in. in diameter, weighing 100 lbs. per mile, all the way from London to Newcastle, 278.08 miles in length, and it became desirable to measure very accurately its electrical elements, so as to see if it possessed, as was anticipated, any marked advantage as a telegraph line over the galvanized iron wires hitherto used.

There were two series of experiments made. In the *first* series the relative electrical condition of the two kinds of wires was determined, and in the *second* series their relative rates of working.

The first series, the results of which are given in tables I., II., III., and IV., was divided into two parts, the one consisting of tests made from Bishop Auckland to Teams, near Newcastle, a distance of 30.235 miles on the north side, and to Pierce Bridge, a distance of 9.172 miles on the south side, and the other consisting of tests of a section of line between Pierce Bridge and Baldersby Cross Roads, 26.7 miles in length. The poles carried ten wires. The tests were made in dry and favorable weather by Messrs. Kempe and Eden.

The electrostatic capacity of an aerial line is known to vary as

$$\log \frac{4h}{d}$$

where h is the height of the wire above the ground, and d its diameter. Now, the average height of the copper wire on the sections between Bishop Auckland and Teams and between Pierce Bridge and Baldersby Cross Roads is 23 feet, and that of the iron wire (on a lower arm of the pole) 22 feet, their diameters being .080 in. and .171 in. respectively. We have, therefore,

1. Read before the British Association at the Aberdeen Meeting, 1885.

for copper wire

$$\log \frac{4h}{d} = \log \frac{4 \times 23 \times 12 \times 1000}{80} = 4.1398791,$$

for iron wire

$$\log \frac{4h}{d} = \log \frac{4 \times 23 \times 12 \times 1000}{171} = 3.7906678,$$

and

$$\frac{3.7906678}{4.1398791} = .916 \text{ nearly},$$

which makes the capacity of the copper wire to be 100 – 91.6, or 8.4 per cent. less than that of the iron wire. This result agrees pretty closely with the mean value of the differences of capacity obtained by actual measurements on these sections—viz., 9.1 per cent.

For the Bishop Auckland-Pierce Bridge section we have,

For copper wire

$$\log \frac{4h}{d} = \log \frac{4 \times 21 \times 12 \times 1000}{80} = 4.1003705.$$

For iron wire

$$\log \frac{4h}{d} = \log \frac{4 \times 20 \times 12 \times 1000}{171} = 3.7492751$$

and

$$\frac{3.7492751}{4.1003705} = .914$$

making the capacity of the copper wire to be 100 — 91.4, or

TABLE I.—*Tests of Copper and Iron Wires on Road Line between* Bishop Auckland *and* Teams Terminal Pole (19th July, 1885).

Designation of wire.	Material.	Gauge.	All wires disconnected except one on lowest arm. Capacity in microfarads.		All wires to earth except one under test. Capacity in microfarads.		Conductor resistance in ohms.		Insulation resistance in megohms.		Remarks.
			Total	Per Mile.	Total	Per Mile.	Total.	Per Mile.	Total.	Per Mile.	
No. 241	Copper	14	.400	.0132	.436	.0144	278.7	9.21	2.709	81.90	Weather fine;
" 242	Iron.	7½	.444	.0146	....	....	346.4	11.45	2.483	75.08	temperature 66
" 243	"	7½	.458	.0151	....	.....	345.0	11.41	1.146	34.65	degrees F. in
" 330	"	7½	.450	.0148	...	.....	345.4	11.42	2.295	69.30	the shade.
" 245	"	7½	.447	.0147	...	.....	345.6	11.43	.513	15.51	Length of section tested
" 329	"	7½	.447	.0147	.510	.0168	345.9	11.44	2.293	69.30	30.235 miles.
Newcastle-Liverpool 3	"	7½	.440	.0145	....	.....	346.2	11.45	1.655	50.04	
Cardiff-Newcastle	"	7½	.440	.0145	...	.....	347.0	11.47	1.862	56.30	
Leeds-Newcastle 2	"	7½	.461	.0152	....	.....	346.7	11.46	1.862	56.30	
Manchester-Newcastle 2.	"	7½	.449	.0148	....	.....	347.0	11.47	2.128	64.34	

TABLE II.—*Tests of Copper and Iron Wires on Road Line between* Bishop Auckland *and* Pierce Bridge (19th July, 1885).

Designation of wire.	Material.	Gauge.	All wires disconnected except one on lowest arm. Capacity in microfarads.		All wires to earth except one under test. Capacity in microfarads.		Conductor resistance in ohms.		Insulation resistance in megohms.		Remarks.
			Total	Per Mile.	Total	Per Mile.	Total	Per Mile.	Total	Per Mile.	
No. 241	Copper	14	.112	.0122	.128	.0139	85.9	9.36	5.730	52.56	Weather fine;
" 242	Iron.	7½	.125	.0136	....	.....	116.5	12 70	4.515	41.41	temperature 66
" 243	"	7½	.123	.0134	....	.....	116.6	12.71	2.980	27.33	degrees F. in
" 330	"	7½	.127	.0138	....	.....	114.9	12.52	4.655	42.70	shade.
" 245	"	7½	.128	.0139	....	.....	113.7	12.40	2.709	24.85	Length of section tested
" 329	"	7½	.128	.0139	.151	.0164	113.9	12.41	3.460	31.73	9.172 miles.
Newcastle-Liverpool 3	"	7½	.130	.0141	....	.....	122.5	13.35	3.725	34.17	All other wires disconnected when capacity of this was measured.
Cardiff-Newcastle	"	7½	.132	.0143	....	.....	114.6	12.50	4.806	44.08	
Leeds-Newcastle 2	"	7½	.132	.0143	...	.....	113.7	12.40	4.515	41.41	
Manchester-Newcastle 2.	"	7½	.128	.0139	....	.....	114.7	12.50	vari	able	

TABLE III.—*Tests of Copper and Iron Wires on Road Line between* Pierce Bridge *and* Baldersby Cross Roads (26th July, 1885).

Designation of wire.	Material.	Gauge.	All wires disconnected. Capacity in microfarads.		All wires to earth except one under test. Capacity in microfarads.		Conductor resistance in ohms.		Insulation resistance in megohms.		Remarks.
			Total	Per Mile.	Total	Per Mile.	Total	Per Mile.	Total	Per Mile.	
No. 241	Copper	14	.319	.0119	.377	.0141	243.5	9.12	1.488	39.732	Weather fine;
" 242	Iron.	7½	.345	.0129	....	.....	327.8	12.27	.893	23.850 [variable]	temperature 76 degrees F. in
" 243	"	7½	.341	.0127	. ..	.....	326.9	12.24	1.030	27.502	shade.
" 330	"	7½	.342	.0128	....	.....	326.6	12.23	.382	10.200	Length of section tested
" 245	"	7½	.351	.0131	....	.... .	326.5	12.23	1.116	30.973	26.7 miles.
" 329	"	7½	.352	.0131	.451	.0169	327.2	12.25	.670	17.892 [variable]	
Liverpool-Newcastle 3	"	7½	.361	.0135	....	.....	326.9	12.24	.346	9.238	
Cardiff-Newcastle	"	7½	.361	.0135	....	.....	327.1	12.25	.670	17.892 [variable]	
Leeds-Newcastle 2	"	7½	.350	.0131	....	.....	326.8	12.24	.893	23 850	
Manchester-Newcastle 2.	"	7½	.350	.0131	...	.....	327.3	12.25	.893	23.850	

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8.6 per cent. less than that of the iron, whilst the actual value was found to be 9.7 per cent. The differences between the calculated and the experimental values are probably due to the influence of trees, buildings, &c., which cannot be allowed for theoretically. These measurements were made when the other wires on the poles were left insulated. The effect of having all the other wires to earth when the capacity of any one wire was measured was very marked. Thus, on one wire the capacity was increased from .352 to .451 microfarad, or 22 per cent. It would therefore appear that the mean capacity per mile of a single iron wire of .171 in. in diameter, placed about 20 feet above the ground, is .0131 microfarad, while an iron wire of the same size, suspended at the same height, but surrounded by other wires forming telegraphic circuits, would have a mean capacity of .0169 per mile. The capacity of copper wire of .080 in. diameter under similar conditions would be about .0120 and .0142 microfarad per mile respectively.

As regards the induction between wire and wire tests the effects obtained were very slight, though their actual value was determined with comparative accuracy.

TABLE IV.—*Tests of New North Road Wires between* PIERCE BRIDGE *and* BALDERSBY CROSS ROADS (26th July, 1885). Induction between Wires.

Primary current wires.	Induced current wires.	Galvanometer deflections. Divisions.	Equivalent in micro-coulombs.	Primary current. Coulombs per sec.	Distance between primary and secondary wires.	Remarks.
					in.	
Nos. 242 and 243	Nos. 330 and 245	20	.0892	.0456	12.8	Weather fine. Temp. 76° F. in the shade.
" "	No. 329 and {Newcastle / Liverpool}	10	.0446	.0456	24.0	Resistance of Galvanometer 6700ω.
" "	{Cardiff / Newcastle} and {Leeds / Newcastle}	5	.0223	.0456	36.3	
Nos. 330 and 245	Nos. 242 and 243	20	.0892	.0456	12.8	Resistance of looped wires, 654ω.
" "	Nos. 329 and {Liverpool / Newcastle}	20	.0892	.0456	12.8	Resistance of battery (30 Daniell's cells), 150ω.
" "	{Cardiff / Newcastle} and {Leeds / Newcastle}	5	.0223	.0456	36.3	
No. 329 and {Liverpool / Newcastle 3}	Nos. 330 and 245	20	.0892	.0456	12.8	(In each case the value of the induced current given is the mean of several measurements.)
" "	Nos. 242 and 243	5	.0223	.0456	36.3	
" "	{Cardiff / Newcastle} and {Leeds / Newcastle}	20	.0892	.0456	12.8	

TABLE V.—*Mean results of speed trials on copper wire between* LONDON *and* NEWCASTLE-ON-TYNE (July, 1885).

Experiment.	Sending power. bichro. cells.	Current passing through receiving instrument in milli-amps.	Form of receiving apparatus.	Arrangement of coils.	Speed, words per minute. Simplex. To London	Simplex. From London	Duplex. To London	Duplex. From London	Compensating capacity in microfarads. Duplex.	Simplex.	Remarks.
A 1 to 4	40	12.3	Wheatstone weight receiver, resistance of coils 100ω each.	Series.	400	414	...	...	......	3.5 to 4	Weather fine, with occasional showers
B 5 to 8	40	12.3	"	Quantity.	400	414	...	...	......	12 to 16	
C 9 to 15	40	12.3	"	....	...	...	265	273	Newcastle 2.75 to 3 G. P. O. 5 to 5.25	....	
D 16 to 20	40	12.3	Relay with coils similar to those in receiver. Receiver in "local" circuit.	Series.	400	414	...	...	......	3.5 to 4	
E 21 to 25	40	12.3	"	Quantity.	400	414	...	...	......	12 to 16	
F 26 to 32	40	12.3	"	....	...	...	265	273	As in C	....	
F F......	40	12.3	As in experiments A, B, and C; but resistance coils and condenser inserted at York in order to make the copper and iron wires alike in resistance and capacity.	... .	400	414	..	...	......	....	
G 33 to 40	40	12.3	Post-office standard relay, receiver in local circuit.	Series.	340	350	...	...	......	4.5	
H 41 to 46	40	12.3	"	Quantity.	340	350	...	...	......	....	
I 47 to 50	40	12.3	"	....	...	...	240	250	As in C	14 to 18	

Length of line, 278.08 miles (including 17.08 miles of underground work); diameter of wire, .08 in.; resistance per mile, 9.1ω: capacity per mile, .0141 M. F. Insulation resistance per mile varied from 3 to 30 megohms.

TABLE VI.—*Mean results of speed trials on Iron Wire between* LONDON *and* NEWCASTLE-ON-TYNE (July, 1885).

Experiment.	Sending power. bichro. cells.	Current passing through receiving instrument in milli-amps.	Form of receiving instrument.	Arrangement of coils.	Speed, words per minute. Simplex. To London	Simplex. From London	Duplex. To London	Duplex. From London	Compensating capacity in microfarads. Duplex.	Simplex.
K 50 to 57	40	12.3	Wheatstone weight receiver, resistance of coils 100ω each.	Series.	338	340	...	...	......	3.5 to 4 (a)
L 58 to 65	40	12.3	"	Quantity.	338	340	...	...	......	12 to 16
M 66 to 76	{50	6 to 15	"	Series.	} 350	...	...	...	......	(b)
	{50	6 to 15	"	Quantity.		...	...	...	......	
O 79 to 82	40	12.3	Relay with coils similar to those in receiver. Receiver in "local" circuit.	Series.	354	360	...	...	......	As in K
P 83 to 89	40	12.3	"	Quantity.	354	360	...	...	......	As in K
Q 90 to 95	40	12.3	"	... .	...	...	231	243	Newcastle 2.75 to 3.25 G. P. O. 5.25 to 5.5.	....
R 96 to 105	40	12.3	Post-office standard relay, receiver in local circuit.	Series.	300	310	...	...	......	....
S 106 to 112	40	12.3	"	Quantity.	300	310	...	...	......	....
T 113 to 120	40	12.3	"	....	...	...	214	224	As in Q	....
N 77 and 78	40	12.3	Wheatstone receiver. Resistance of coils 100ω each.	....	...	..	231	243	As in Q	....

Length of line, 278.08 miles (including 6 miles of No. 14 copper wire; and 17.08 miles of underground work); diameter of iron wire, .171 in.; resistance of iron wire, 12.15ω per mile; capacity of iron wire, .0169 M. F. per mile. Average insulation resistance 20 megohms per mile.

REMARKS.—(*a*) Weather fine, with occasional showers; (*b*) Various combinations of resistance and capacity tried.

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The second series of experiments were conducted between London and Newcastle, and were designed, as stated above, to test the working efficiency of the copper wire as compared with iron wires. They were conducted by Messrs.

TABLE VII.—*Comparative Speeds obtained on Copper and Iron Wires under similar conditions.* (Summary of Tables V and VI.)

Words Per Minute.								Average increase of speed on copper wire.
Iron.				Copper.				
Simplex.		Duplex.		Simplex.		Duplex.		
To London	From London	To London	From London	To London	From London	To London	From London	Per cent.
333	340	...	...	400	414	...	...	21.
...	...	231	243	...	...	265	278	11.36
354	360	...	...	400	414	...	...	11.40
...	...	231	243	...	...	265	278	11.36
300	310	...	...	340	350	...	...	11.31
...	...	214	224	...	...	240	250	11.19
				Mean result of all experiments....				12. 9

Chapman and Eden. The results of the numerous trials of speed with various arrangements of the apparatus are given in tables V. and VI., and are summarized in table VII.

It will be observed that copper shows a very decided superiority over iron, the speeds being as follows:—

	Copper.	Iron.	
Simplex working....	414........	345	words per minute.
Duplex "	270........	237	" "

It is anticipated that the superiority of copper over iron indicated by these experiments will have a beneficial and economical influence on our telegraph system, and that its extended use will enable us not only to work better, but to dispense with intermediate repeaters in many cases where, on long lines, they are now necessary.

The most interesting point, however, in connection with these experiments is that they apparently prove that the superiority of copper is not simply due to its smaller electrostatic capacity and resistance, but that it is more susceptible to rapid changes of electric currents than iron; for when the resistance and capacity of the copper and iron wires were equalized by the insertion of resistance coils and condensers, the speed on the former was not thereby diminished. Possibly the magnetic susceptibility of the iron is the cause of this. The magnetization of the iron acts as a kind of drag on the currents. It is well known that telephones always work better on copper than on iron wires, doubtless for the same reason.

These experiments also show the high speed of working that is now attained by the post-office authorities with the Wheatstone automatic apparatus. The following table gives an interesting *resumé* of the different stages of the progress made, and its rate of growth:—

1877..........................	80	words per minute.
1878..........................	100	" "
1879..........................	130	" "
1880..........................	170	" "
1881..........................	190	" "
1882..........................	200	" "
1883..........................	250	" "
1884..........................	350	" "
1885..........................	420	" "

JUDICIAL WARPING OF PATENTS.

UNDER this heading Prof. Silvanus P. Thompson, of Finsbury Technical College, has written as follows to the London *Times*:—"In the columns of your law report of to-day there occurs a most extraordinary instance of the evil tendency at present prevading the practice of even our highest courts of warping or straining the language of a patent specification so as to make it read in some forced sense in favor of a patentee who is backed up by wealthy supporters. This evil tendency, which is deliberately fostered by eminently leading counsel and by a few professional experts, who lend themselves to this mode of securing a monopoly for the patentee, is rapidly bringing into discredit the administration of the patent laws. The present instance, which occurred in the Appeal Court in the case of 'United Telephone Co. *v.* Bassano,' arose in the following way. The defendants, who are a small provincial firm of telegraph engineers, had constructed a telephone transmitter in a manner which they honestly believed to be different, not only in design, principle, and mode of action, but even in the materials employed, from the transmitter invented by Edison, the American, whose patent is held by the plaintiff company. There had been some question whether the 'tension-regulator' or mechanism of the defendants' instruments was or was not substantially the same as that described in the Edison specification. Lord Justice Cotton, in giving judgment on this point, made the following statement:—'Edison had mentioned several sorts of tension-regulators, but in that which had been ultimately preferred there were fixed blocks and suspended pencils of carbon which acted by varying the tension according to the distance between the carbon points.' That is a very clear statement of what the learned judge considered the defendants to have infringed. But now comes the extraordinary fact that not only is this passage not quoted from the Edison specification, but there is absolutely nothing in the Edison specification even to support it. 'Fixed blocks and suspended pencils of carbon,' 'distance between the carbon points,' are not suggested and never were suggested by Edison. The words 'fixed blocks' and 'suspended pencils' are never mentioned by Edison. Nay, even the substance 'carbon' is never once named by Edison. The nearest approach to all this in the Edison document is tufts of silk fibre covered with plumbago, or with volatilized metals, and lampblack contained within a case. That a high court of justice can be so influenced by eminent advocates as to be able to warp and strain tufts of metallized silk and cases full of lampblack into 'fixed blocks and suspended pencils of carbon,' and then to add that 'it was not the duty of the court to point out the exact particular of the construction to which the infringement was due,' is one of those things which would be incredible if it had not actually occurred yesterday. But can any one explain how or why it is that not only in suits about telephones, but in suits about gas engines and electric lights, the same process of judicial warping of patents has gone on?"

In reply to Prof. Thompson's letter, Mr. John Imray, the well-known patent agent, wrote:—"Under the heading "Judicial Warping of Patents" Prof. Silvanus P. Thompson, in a letter published in your issue of this date, alleges that judges and justices of appeal are misled by counsel and expert witnesses to such an extent that they quite misunderstand patent specifications, and, consequently give unjust judgments. The learned professor does not think it necessary to mention that he has himself condescended to perform the part of an expert witness, but as he has happened to be on the wrong side, *hinc illæ lachrymæ.* In the case referred to by Prof. Thompson, that of Edison's telephone patent, a new invention of an important and fundamental character had to be dealt with by the judges. It was not, like most patented inventions, a mere improvement in constructive details or in specific arrangements or combinations; it was an altogether a novel departure, which, coupled with Bell's great invention, has led to a system of communication marvelous as it is useful. In such a case judges who know their duty do not tie down the invention to the precise details given by the inventor; they look for the principle on which the invention is based, they ascertain what is the spirit and essence, the 'pith and marrow' of the invention, and, if they see that, nothwithstanding variations of form, material, or arrangements of parts, some rival apparatus has in fact the 'pith and marrow' of the original, they justly pronounce that to be an infringement."

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THE INVERSE ELECTROMOTIVE FORCE OF THE VOLTAIC ARC.

BY CHAS. R. CROSS AND WM. E. SHEPARD.[1]

THE fact that the total or equivalent resistance of a voltaic arc consists of two parts, the one constant for the same current, the other variable in proportion to the length of the arc, was first made known by Edlund in 1867 and 1868 (*Poggendorff's Annalen*, vol. cxxxi., p. 586; vol. cxxxiv., p. 250). This total resistance, r, is evidently represented by the equation $r = a + bl$, and if the constant a be multiplied by the current, C, employed, the inverse electromotive force is found.

Later researches have shown conclusively, with the silent arc, throughout a great range of length and of current strength, that this product, $a\ C$, is approximately constant.

The most recent results on this subject are those of Fröhlich (*Elektrotechnische Zeitschrift*, vol. iv., 1883, p. 150), whose results give a value of 39 volts for the quantity $a\ C$; of Peukert (*Zeitschrift für Elektrotechnik*, vol. iii., 1885, p. 111), who finds a mean value of 35 volts for currents of 10 ampères and over; and Von Lang (*Centralblatt für Elektrotechnik*, vol. vii., 1885, p. 315; p. 446), who assigns a value of 39 volts.

It has long been known that on the passage of the arc from the whistling to the silent stage, as the carbons are separated, there is a sudden rise in the difference of potential between them. At the same time the arc becomes much brighter and hotter, from which we should naturally infer that the conductive resistance would diminish. The current, however, is at the same time diminished.

These facts might lead one to infer the probability of there being a sudden rise in the inverse electromotive force of the arc at the point when whistling ceases. So far as we are aware, this point had not been studied previous to the observations which we have to present.

The quantity $a\ C$ was originally supposed by Edlund to be of the nature of an opposing electromotive force. It is true that this view has not been accepted without question, and that the real cause of the phenomena under consideration is still somewhat uncertain; but we shall, nevertheless, in this paper, for convenience of description, refer to this quantity $a\ C$ as the inverse electromotive force of the arc.

The object of the experiments described in the present paper was to review the results of earlier observers on the quiet arc, to extend the observations to the whistling arc, and to observe the effect on the inverse electro-motive force of the arc caused by variations in the position and temperature of the electrodes, by the presence of volatilized substances in the arc, and by variations in the density of the air in which the arc is formed.

A lamp was constructed for the purpose whose upper carbon was movable in a vertical direction by a micrometer screw, having a pitch of $\frac{1}{32}$ of an inch. Wires ran from brass collars surrounding the carbons and as near as possible to their extremities, to a voltmeter, which gave the difference of potential between the carbons. The current of electricity was usually furnished by a Brush dynamo machine. It was measured in some cases by means of a carefully and frequently calibrated Ayrton and Perry permanent magnet ammeter, and in others by a Paterson and Cooper electro-magnet ammeter, also calibrated by comparison with standard instruments. A similarly calibrated Ayrton and Perry permanent magnet voltmeter was employed for the potential measurements. Reversals of readings were obtained by a mercury commutator so arranged as to reverse both the current and potential instruments simultaneously. The quotient of the difference of potential between the carbons divided by the current gave the equivalent resistance of the arc. Care was taken that the arc should be formed so as to pass between those points of the carbons which were closest together, which was secured by filing them flat. The separation between the points as measured by the micrometer, therefore, gave the length of the arc. It was of course necessary to make the measurements with a sufficient degree of quickness, so that no sensible burning away should occur before they were finished. No difficulty was found in doing this, as it took a number of seconds for the filed carbons to shorten by any material amount. Before each set of measurements the carbons after filing were screwed into contact, the reading of the micrometer taken, and the carbons were then separated by the desired amount. It was found, however, that the expansion of the carbons by heat was a noticeable quantity, and hence, except with very long arcs, the arc was allowed to form, and then the carbons were quickly screwed into contact and again separated by the desired amount. For arcs so long that this was not practicable, the expansion was estimated and allowed for. The change of reading from this cause appeared to vary from $\frac{1}{10}$ to $\frac{1}{4}$ of a revolution of the micrometer screw; that is, from $\frac{1}{320}$ to $\frac{1}{128}$ of an inch. In order to avoid undue disturbance of the dynamo during the measurements, the dynamo circuit was never broken, but by means of a suitable key the current was thrown into a wire resistance approximately equivalent to the arc resistance before the arc was broken. The current forming the arc was regulated by means of suitable resistance coils interposed in the circuit.

In most of the measurements Boulton carbons were used. Ten successive measurements with reversals were usually made in each series, keeping the current and electromotive force as nearly constant as possible, and taking the mean value as the result of one set of measurements for the length of arc used. The following two tables, taken at random, are given in full to indicate the degree of variation observed. One of the tables shows results with a quiet arc, one with a whistling arc. The column headed A contains the scale readings of the ammeter; that headed V, those of the voltmeter. The mean of each of these is taken, and the current and electromotive force desired are then found by multiplication of the mean by the proper instrumental constants, which, with the tables given, are 1.00 for the ammeter and 2.12 for the voltmeter.

TABLE I.

Length of Arc = $\frac{3}{32}$ in.

Silent.

A.	V.
5.3	21.2
5.3	21.5
4.9	22.2
5.1	21.0
5.1	21.7
5.1	21.2
4.8	22.7
5.0	21.2
4.9	22.0
4.8	22.2
5.1	22.2
5.2	21.8
5.1	22.2
5.1	22.2
5.1	23.0
5.2	22.8
4.8	23.8
4.9	23.7
4.8	24.2
4.5	24.5
Mean, 5.00	22.37

C = 5.00 ampères.
E = 47.42 volts.
R = 9.48 ohms.

TABLE II.

Length of Arc = $\frac{3}{32}$ in.

Whistling.

A.	V.
5.2	19.0
5.3	18.2
5.1	18.2
5.1	18.2
5.2	18.2
5.2	18.2
5.3	18.0
5.1	19.0
4.9	19.0
4.8	19.8
4.8	19.0
4.8	19.0
5.1	18.8
5.2	18.2
5.1	18.5
4.9	19.2
4.9	18.8
5.0	18.2
5.0	19.0
5.0	19.0
Mean, 5.05	18.67

C = 5.05 ampères.
E = 39.59 volts.
R = 7.84 ohms.

Owing to the great variability of the arc, it is of course impossible to avoid having a considerable average deviation with a series of successive measurements of current and electromotive force; but, as will be seen, in spite of the

1. Read at a meeting of the American Academy of Arts and Sciences, June 16, 1886.

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necessarily large limits of variation, consistent results are nevertheless obtainable.

About 1200 measurements were taken embracing 60 series of 10 readings with reversals, using lengths of arc of from $\frac{1}{16}$in. to $\frac{1}{4}$in., and currents varying from 3 to 10 ampères. Ordinarily we made a series of measurements with increasing lengths of arc, keeping the current as nearly constant as possible by means of resistance coils. The variations in the current were rarely more than a few hundredths of an ampère, and as the current was measured simultaneously with the electromotive force, these small changes did no harm. The equivalent resistance for each length of arc with the various strengths of current was obtained from the data given by the measurements. The following tables show the results reached. The first column gives the separation of the carbons, which is the length of the arc, the unit being $\frac{1}{32}$ of an inch, the second column gives the equivalent resistance in ohms, which is the electromotive force between the carbons divided by the corresponding value of the current; the third column states whether the arc was a silent (s) or whistling (w) one. The value of the current given over each table is the mean of the values found in the various separate measurements.

UPRIGHT ARC.

TABLE III.

Current 3.27 Ampères.

Length of arc.	Resistance.	Character.
.25	5.51-5.93	W.
.50	7.41	"
.50	6.96*	"
1.00	9.50	"
1.00	9.86*	W. (slightly.)

* These results were given by Carré carbons.

TABLE IV.

Current = 5.04 Ampères.

Length	Resistance.	Character.
1	5.67	W. (slightly.)
2	8.14	S.
3	9.51	"
4	10.02	"
5	10.57	"
6	11.10	"
7	11.60	"

TABLE V.

Current 7 Ampères.

Length	Resistance.	Character.
.25	2.49	W.
.50	2.89	"
1	3.60	"
1	3.55	"
2	5.28	"
2	5.17	" (low.)
3	6.28	S.
3	6.41	"
4	6.77	"
4	6.72	"
5	6.97	"
6	7.25	"
7	7.51	"
8	7.80	"
9	8.06	"
12	8.97	"
12	8.90	"
14	9.31	S. (flaming.)

TABLE VI.

Current = 7.94 Ampères,

Length	Resistance.	Character.
.50	2.42	W.
1	3.09	"
2	4.58	W. (slightly.)
3	5.60	S.
4	6.04	"
5	6.32	"
6	6.49	"
7	6.73	"
8	7.14	"
10	7.51	"
12	8.09	"
14	8.57	"
16	8.89	"

TABLE VII.

Current = 10.04 Ampères

Length	Resistance.	Character.
.50	1.86	W.
1	2.30	"
1	2.19	"
1	2.34	"
2	2.95	S.
3	3.94	"
3	3.74	W. (low.)
4	4.45	S.
5	4.67	"
6	4.91	"
7	5.08	"
8	5.32	"
8	5.22	"
10	5.66	S. (flaming.)

From the measurements as given in the tables, curves were next plotted on a large scale for each mean strength of current, with the separations of the carbons as abscissæ and the corresponding resistances as ordinates.

These curves were in all cases found to be composed of two straight lines, the intersection of which corresponds approximately to the point at which the arc, as it is gradually lengthened passes from a whistling to a silent one. The curve for the whistling arc is the steepest. Hence, for the curve corresponding to each strength of current there are two different intercepts and two different angles made with the axis of abscissæ, according as the arc is whistling or silent. Since the intercept gives the quantity a in the general equation $r = a + bl$, which quantity being multiplied by the current gives the corresponding value of the inverse electromotive force of the arc, it follows that for any particular current there is a definite opposing electromotive force for the whistling arc as for the silent arc, whatever its length, but that the former is different from the latter, and less than it. Also, there is for the whistling arc, as well as for the silent arc with any definite current, a definite value of b, and hence, a simple proportionality between the variable portion of the equivalent resistance and the length. The values of b are greater with the whistling than with the silent arc for the same current strength.

From the curves plotted as described, the linear equations of the two branches corresponding to the silent and whistling arcs were obtained. These are given in tables VIII. and IX., and are numbered for convenience of reference. The length, l, is expressed in terms of the pitch of the micrometer screw, *i. e.*, in thirty-seconds of an inch. The current is expressed in ampères. Lengths of arc up to $\frac{16}{32}$ in. were observed.

TABLE VIII.

SILENT ARC.			
Current.	No.	Equation.	E. M. F. = $a \times C$.
5.04	1	$r = 7.97 + .515\,l$	40.16
7.00	2	$r = 5.73 + .261\,l$	40.11
7.92	3	$r = 5.00 + .256\,l$	39.60
10.04	4	$r = 3.73 + .198\,l$	37.45
			Mean..39.33

TABLE IX.

WHISTLING ARC.			
Current.	No.	Equation.	E. M. F. = $a \times C$.
3.27	5	$r = 4.70 + 4.90\,l$	15.37
5.03	6	$r = 3.14 + 2.53\,l$	15.79
7.00	7	$r = 2.10 + 1.'5\,l$	14.70
7.95	8	$r = 1.81 + 1.26\,l$	14.39
10.03	9	$r = 1.46 + 0.787\,l$	14.64
			Mean..14.98

The fourth column of the table gives the inverse electromotive force corresponding to each current, as found by multiplying the intercept given in the equation by that current. It appears from the results, that for the silent arc the mean value of the inverse electromotive force is approximately 39 volts. There is, however, an evident diminution in this value as the current rises, and by reference to the equations given in Peukert's paper, already cited, it will be seen that they also indicate the probability of such a change.

When the arc becomes very long there is an apparent tendency to an abnormally small value of the equivalent resistance. This was observed in the values of the resistance when the arc was $\frac{14}{32}$ in. long, with a current of 7 ampères, and when the arc was $\frac{16}{32}$ in. long with a current of 8 ampères. It was also noticed with very long arcs in which metallic salts were volatilized.

Table IX. also shows us an additional fact. Not only is the inverse electromotive force of the silent arc the same

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for any given current, irrespective of the length of the arc (within the limits of whistling), but it also has, like that of the silent arc, an approximately definite value for all currents. The mean of the results with the silent arc given in the table, is about 15 volts. There is, also (notwithstanding some anomalous results), the same manifest diminution with increase of current that we observe with the silent arc. It will further be noticed, that the constant, *b*, diminishes as the current increases, but that its value is several times as great for the whistling as for the silent arc.

For both the silent and whistling arcs, the conductive resistance (bl) diminishes as the current is increased, at first rapidly, afterwards more slowly.

The equations verify previous observations, in that the passage from higher to lower inverse electromotive force is a sudden one. It takes place with a greater separation of the carbons, and less equivalent resistance, as the current is stronger, a result agreeing with that reached by White from direct measurements. (*Electrician*, vol. xiv, 1884, p. 56.) The following figures (table x.) taken from the curves as plotted, illustrate this: The first column gives the approximate current, the second the equivalent resistance, the third, the separation of the carbons, at which the change would take place, which last is, of course, the abscissa of the point of intersection of the two straight lines representing the two varieties of arc.

TABLE X.

Current.	Equivalent resistance.	Distance between carbons.
5.0	9.22	$\frac{2.4}{32}$ = .075 in.
7.0	6.47	$\frac{2.8}{32}$ = .087 in.
7.9	5.83	$\frac{3.2}{32}$ = .100 in.
10.0	4.46	$\frac{3.8}{32}$ = .119 in.

These values would doubtlessly vary considerably with the nature of the carbons used for the electrodes.

It was also noticed with the stronger currents, that on lengthening the arc, the whistle ceased slightly before the higher inverse electromotive force was reached. This appeared to be somewhat influenced by the quality of the carbons. In all cases, however, the line of demarcation between the silent and the whistling arc was very definite. With the whistling arc, there was always great unsteadiness, which was very much diminished at the moment when the arc became quiet. At the same time the positive carbon suddenly brightened, indicating a great rise of temperature.

A quite interesting peculiarity was noticed in the curves for the whistling arcs. As will also be seen from the equations, the lines all converge approximately towards a point situated behind the axis of ordinates, and corresponding algebraically to a negative separation of about $9 \times \frac{1}{32}$ inches, the corresponding algebraic value of the resistance being about $\frac{7}{10}$ ohms. This property of the curves furnishes a means of finding approximately the equivalent resistance of any whistling arc, as follows: Divide the average value of the inverse electromotive force, 15.13 volts by the strength of the current, which gives the intercept, *a*, corresponding to the current in question. Draw a line from the point of convergence as given above, through the upper point of the intercept, and it will be the curve for this current. The ordinate corresponding to any abscissa gives the equivalent resistance for that length of arc. The curve for the smallest current used, 3.27 ampères, alone shows much deviation from the rule. The curves for the silent arcs do not show any such definite point of convergence.

It is interesting to examine Edlund's early values for the inverse electromotive force in the light of the preceding results. His first values are expressed in units which are purely arbitrary. They show, however, approximately the same figure for *a C* through a considerable range of variation in the strength of the current. His later results give 9.7 as the value of the inverse electromotive force with a current of 30 Bunsen elements, the electromotive force of a Bunsen cell being taken as a unit. With 50 elements its value rose to 15. It seems probable that the former result was reached with a whistling arc, and the latter with a silent one. It is difficult to explain the existence of certain intermediate values, but the method by which they were obtained is liable to great errors.

If we consider Peukert's paper we find that the results from which he derives his value of 35 do not include any with a less current than 10 ampères, and but one in which the length of the arc is less than 2 mm., so that the arcs were probably all silent. The observations from which Fröhlich constructs the curve giving the value of 39 are too irregular to show any difference that might exist between the values of the constant for the silent and for the whistling arcs. Von Lang states that the arcs measured by him were carefully kept from hissing by manual adjustment.

A large number of measurements were made with an inverted arc, in which the positive carbon was below and the negative one above.

Currents of approximately 5, 7, and 10 ampères were used, with lengths of arc up to $\frac{7}{32}$ inch. There was much unsteadiness in the voltmeter for arcs more than $\frac{3}{32}$ inch long, there being a slow and irregular fluctuation of the needle between definite limits. Very probably this was due to irregularities in the air currents rising from the lower and hotter positive carbon. In some sets of the measurements (series ii. of tables) the extreme readings were taken and separate curves drawn for each. The following tables (xi. to xvii.) give the results of the measurements.

INVERTED ARC.—SERIES I.

TABLE XI.
Current = 5.1 ampères.

Length.	Resistance.
.50	3.88
1	4.91
2	7.50
3	9.00
4	9.50
5	9.90
6	10.60

TABLE XII.
Current = 7.8 ampères.

Length.	Resistance.
1	3.22
2	4.64
3	5.85
4	6.49
5	6.76
6	6.91
7	7.14
8	7.38

INVERTED ARC.—SERIES II.

TABLE XIII.
Current = 5.1 ampères.

Separation	Resistance.	
	Minimum.	Maximum.
.50	3.86	....
1	5.05	5.48
2	6.98	8.23
3	8.81	9.52
4	9.33	10.33
4.	9.14	9.97
5	9.52	10.60
6	9.81	11.01
7	10.40	11.43
8	10.40	12.00
9	10.80	12.50

TABLE XIV.
Current = 10.2 ampères.

Separation	Resistance.	
	Minimum.	Maximum.
3	3.06	3.83
4	3.60	4.70

TABLE XV.
Current = 9.6 ampères.

Separation	Minimum.	Maximum.
5	4.10	5.17
6	4.18	5.27
7	4.18	5.60

The curves for the inverted arc were constructed, as already explained for the upright arc. These were found, as with the latter, to consist of two distinct straight lines, corresponding to the silent and the whistling arcs respectively. The following equations (tables xv., xvi.) represent the results obtained. Equations 10 and 12 were found by taking the extreme readings as described, the current being steady at 5.1 ampères. Equation 11 was obtained from another series of experiments, using the same strength of current, but taking the mean reading of the voltmeter at each observation. Equations 14 and 15 were constructed

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from the extreme readings. The current varied slightly with these last, the average value being 9.6 ampères for the silent arc and 10.2 ampères for the whistling arc. The inverse electromotive force is given in the last column of the table.

TABLE XV.

SILENT ARC.			
Current.	No.	Equation.	E. M. F. = $a \times C$.
5.1 (*max.*)	10	$r = 7.70 + .540\,l$	39.27 } 39.27
5.1	11	$r = 7.70 + .450\,l$	39.27 } 39.27
5.1 (*min.*)	12	$r = 7.70 + .367\,l$	39.27 } 39.27
7.3	13	$r = 5.60 + .214\,l$	40.88 - 40.86
9.6 (*max.*)	14	$r = 4.01 + .230\,l$	38.50 } 38.07
9.6 (*min.*)	15	$r = 3.92 + .052\,l$	37.63 } 38.07
			Mean..39.41

TABLE XVI.

WHISTLING ARC.			
Current.	No.	Equation.	E. M. F. = $a \times C$.
5.1 (*max.*)	16	$r = 2.95 + 2.67\,l$	15.04 } 14.71
5.1	17	$r = 2.85 + 3.07\,l$	14.54 } 14.71
5.1 (*min.*)	18	$r = 2.85 + 2.03\,l$	14.54 } 14.71
7.3	19	$r = 1.95 + 1.32\,l$	14.23 - 14.23
10.2 (*max.*)	20	$r = 1.30 + .846\,l$	13.26 } 13.26
10.2 (*min.*)	21	$r = 1.30 + .583\,l$	13.26 } 13.26
			Mean..14.07

It will be seen from the figures in the last column that the fluctuations of the voltmeter to which we have referred were, for the most part, due to variations in the conductive resistance of the arc, the inverse electromotive force being almost constant for the same current, notwithstanding the variations occurring in the total resistance. With the whistling arc the inverse electromotive force is decidedly less for the same current in the inverted than in the upright arc, and the same is probably true to a less degree with the silent arc, though this is not so clearly shown in our observations, partly on account of an exceptionally high value for the inverse electromotive force with the current of 7.3 ampères and inverted arc.

It will also be observed that the corresponding values of the conductive resistance (bl) and the total equivalent resistance are both somewhat less for the inverted arc. This differs from a result somewhat doubtfully recorded by Niaudet (*Machines electriques a courants continus*; p. 133).

The points of intersection of the lines corresponding to the two varieties of the inverted arc are given in the following table, as read from the curves. They may also, of course, be obtained by solution of the equations.

TABLE XVII.

Current.	Equivalent Resistance.	Distance between carbons.
5.1 (*max.*)	8.92	$\frac{2.2}{32}$ = .069 in.
5.1	9.05	$\frac{3.0}{32}$ = .094 in.
5.1 (*min.*)	8.74	$\frac{2.9}{32}$ = .091 in.
7.3	6.32	$\frac{3.3}{32}$ = .103 in.
9.6–10.2 (*max.*)	5.02	$\frac{4.4}{32}$ = .137 in.
9.6–10.2 (*min.*)	4.16	$\frac{4.9}{32}$ = .153 in.

Comparing this with the table already given for the upright arc, it appears that with the inverted arc the length at which the higher inverse electromotive force sets in is somewhat greater. The corresponding equivalent resistance is not greatly different in the two cases.

Measurements were also made of the resistance of arcs into which certain metallic salts had been introduced. The salt, in powder, was placed on the lower (negative) carbon while this was quite hot, care being taken to entirely cover the carbon point, and to keep the powder from being jarred off on forming the arc. The reading of the voltmeter for a given length of arc remained quite constant for a short time after the arc was established, so that readings could readily be obtained.

Observations were made with arcs containing biborate of soda, sulphate of soda, and sulphate of potash. The arcs employed were from $\frac{1}{32}$ to $\frac{4}{32}$ in. in length with the biborate of soda, from $\frac{1}{32}$ to $\frac{5}{32}$ with the sulphate of soda, and from $\frac{1}{32}$ to $\frac{16}{32}$ with the sulphate of potash. The current was approximately 5 ampères. The equation $r = a + bl$ still expressed the results as follows:

TABLE XVIII.

Current	Salt.	No.	Equation.
5.10	Biborate of Soda	22	$r = 1.25 + .290\,l$
4.94	Sulphate of Soda	23	$r = 2.20 + .418\,l$
5.10	Sulphate of Potash	24	$r = 1.77 + .223\,l$

The values of the inverse electromotive force were for biborate of soda 6.38 volts, for sulphate of soda 10.86 volts, and for sulphate of potash 9.03 volts. The conductive resistance, as well as the inverse electromotive force, is diminished by the presence of the salts in the arc.

The data from which the curves giving the preceding equations were constructed, are given in the following tables:

TABLE XIX.
Biborate of Soda.
Current = 5.10 ampères.

Length.	Resistance.
1	1.53
2	1.82
3	2.12
4	2.41

TABLE XX.
Sulphate of Soda.
Current = 4.94 ampères.

Length.	Resistance.
1	2.64
2	2.98
3	3.43
4	3.85
5	4.00

TABLE XXI.
Sulphate of Potash.
Current = 5.10 ampères.

Length.	Resistance.
1	2.00
2	2.21
3	2.49
4	2.71
5	2.96
6	3.08
7	3.29
9	3.82
11	4.21
13	4.58
15	4.91

Whatever may prove to be the real cause of the inverse electromotive force of the arc, it is clear that it is intimately connected with variations in the temperature of the carbons. Thus both the actual temperature and the difference of temperature between the carbons is greater with the silent than with the whistling arc, and at the same time the inverse electromotive force of the former is the higher. Again, the temperature of the carbons is apparently lowered when metallic salts are introduced into the arc, and the inverse electromotive force falls at the same time. Edlund (*Pogg. Ann.*, vol. cxxxiv., p. 250) found that by heating the negative carbon by a blast-lamp, the inverse electromotive force was raised; but this was not the case when the flame of the lamp was directed against the positive carbon, and in fact there then seemed to be a fall. It seems very probable that this last result came from the fact that the positive carbon was so much hotter than the flame that the effect of the latter was on the whole to cool the arc. We endeavored to increase the temperature of the positive carbon in a different manner, by surrounding it with a deep cup-shaped shield of fire-clay, which projected over the end of the carbon so as to envelop the arc, thus preventing radiation. At the same time a broad, flat, horizontal plate of brass was attached to the lower and negative carbon. This obstructed the access of air to the arc, and thus tended to keep up its temperature.

A current of 7 ampères was employed, with arcs varying from $\frac{1}{32}$ to $\frac{12}{32}$ in. in length. As the carbons could not be filed in these experiments, the length of the arc was obtained by screwing the points into contact while the current

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was passing and then separating them to the required distance. A moderately high wire resistance was placed in the circuit with the arc, so that there was no material change in the strength of the current and condition of the dynamo machine caused by this adjustment of the carbons, and the needed measurements could be made rapidly. There was considerable periodic fluctuation of the reading of the voltmeter, as had been noticed previously with the inverted arc, and two curves were drawn corresponding to the extreme readings. The current was sensibly constant. The highest set of values for the equivalent resistances corresponding to different lengths of arc are satisfied for the silent arc by the equation (25) $r = 6.70 + .16\,l$, and for the whistling arc by the equation (26) $r = 3.02 + 1.10\,l$. The corresponding values of the inverse electromotive force are 46.9 volts, and 21.1 volts. The lowest set of values are satisfied by the equations (27) $r = 6.70 + .09\,l$ for the silent arc, and (28) $r = 3.02 + .97\,l$ for the whistling arc. The corresponding values of the inverse electromotive force are the same as before, viz.: 46.9 and 21.1, respectively, showing that the changes observed in the difference of potential between the carbons were due to variations in the conductive resistance, and not to variations in the inverse electromotive force of the arc. These resistance variations, while amply large to affect the readings of the voltmeter, were too small to produce any sensible change in the strength of the main current. It also appears by a comparison of the equations just given for the shielded arc with equations (2) and (7) that the coefficient of l is decidedly less with the shielded arc, showing that the conductive resistance of the arc is diminished by the increased temperature, as would be anticipated. The increased inverse electromotive force is much greater than we had expected to find it, and at first might lead one to surmise why, with the ordinary arc, the inverse electromotive force does not rise with increased strength of current. This is probably to be explained by the fact that the chief effect of an increase in current is to heat a larger area of the carbons to the same temperature, rather than to raise them to a considerably higher temperature.

Observing the position of the point of intersection of the lines representing the silent and whistling arcs, we find that the passage from low to high inverse electromotive force occurs with a length of arc of $\frac{3.92}{32} = .123$ inches for the line represented by equation (26) and of $\frac{4.20}{32} = .131$ inches for that of equation (28) which values are greater than those occurring with the normal arc and the same strength of current. The corresponding equivalent resistances are 7.34 ohms and 7.07 ohms.

We next tried the reverse experiment of cooling the upper positive carbon. This was done by surrounding the lower end of the carbon with a brass tube through which a current of cold water flowed. The negative electrode was left in its usual condition. The arc under these conditions was extremely unstable, the slightest breath would extinguish it, and even with a current of 10 ampères it could not be elongated to a greater length than $\frac{3}{32}$ of an inch. It was quite blue, whistled, and gave but very little light. The extreme length of arc used was $\frac{3}{32}$ in. with the weaker, and $\frac{2}{32}$ in. with the stronger current. Plotted curves gave the following equations, satisfying the observations with tolerable exactness:

Current.	No.	Equation.
7	29,	$r = 1.67 + 1.11\,l.$
8	30,	$r = .70 + 1.82\,l.$

The corresponding inverse electromotive forces are 11.7 volts and 5.6 volts respectively. Both of these are much below the value already found for the whistling arc under normal conditions. But we also find here, for the first time, a great difference between the inverse electromotive force with different currents. As with the normal arc, the higher value occurs with the lesser current. With the current of 7 ampères the conductive resistance is lower than with the normal arc, but with 8 ampères it is higher. Owing to the low inverse electromotive force, the total resistance is considerably less with both strengths of current.

It was our intention to observe also the effect of cooling the negative carbon, but this was prevented by an accident to the apparatus. There is no reason to suppose, in the light of Edlund's experiments already cited, that this would have made any change in the results.

This fall of inverse electromotive force with lowered temperature of the arc may be the explanation of the fall which occurs with the inverted arc, as the increased convection when the hot positive crater is turned upward may be sufficient to lower the temperature by a slight amount.

The following tables give the data from which our equations were determined:

TABLE XXII.
Positive Carbon Heated.
Current = 7 ampères.

Length.	Resistance. Minimum.	Resistance. Maximum.
1	3.86	4.24
2	4.91	5.15
3	5.90	6.36
4	6.97	7.42
5	7.42	7.42
6	7.27	7.66
7	7.31	7.88
8	7.21	7.97
9	7.57	8.10
10	....	8.48
11	....	8.64
12	....	9.10

TABLE XXIII.
Positive Carbon Cooled.
Current = 7 ampères.

Length.	Resistance.
1	2.72
2	3.96
3	4.99
Current = 8 ampères.	
1	2.52
2	4.35

For observations on the arc formed under diminished pressure and in different gases, a metallic receiver was constructed in which the rod carrying the upper carbon passed through the closed top of the receiver, and was movable by means of a micrometer screw. A window set in the side of the receiver, allowed observation of the arc. The exhaustion could be read by an attached gauge. The rubber screw plug, through which the rod passed was covered with oil or glycerine to diminish the leakage. The construction of the apparatus was greatly delayed by unforeseen circumstances, so that up to the present date we have been able to make only a very few experiments. Some difficulty has also been met with from the heating and vaporization of portions of liquid which have leaked into the receiver. This was partially avoided by immersing the receiver in water. In the experiments thus far made with this apparatus, the pressure was 4 inches of mercury. Currents were employed of 5, 7.95 and 9.86 ampères respectively, with lengths of arc from $\frac{1}{64}$ to $\frac{6}{32}$ inches. In all the experiments the positive carbon was uppermost. The arc was found to be a whistling one up to the extreme limits obtained. The results of the experiments are given in table XXIV.

TABLE XXIV.

Current = 5.00 ampères.

Length.	Resistance.
.50	3.70
1	4.42
1	4.33
2	5.38
2	5.38
3	7.12*
3	7.12*
4	7.68

Current = 7.95 ampères.

Length.	Resistance.
.50	1.69*
1	2.45
1	2.57
2	3.06
2	3.21
3	3.70
3	3.66
4	4.28
4	4.17
5	4.93
5	4.80
6	5.51
6	5.37

Current = 9.86 ampères.

Length.	Resistance.
.50	1.75
1	1.97
1	2.09
2	2.42
2	2.42
3	2.74
3	2.92
4	3.32
4	3.14
5	3.86

* These values deviate greatly from the curves.

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These results, when plotted as before, give straight lines, represented by the following equations :

TABLE XXV.

Current.	No.	Equation.	E. M. F. = $a \times C$.
5.00	31	$r = 3.30 + 1.09\,l$	16.50
7.95	32	$r = 2.00 + .57\,l$	15.90
9.86	33	$r = 1.70 + .38\,l$	16.76
			Mean..16.39

These lines are all less inclined than those for the same current with whistling arc under normal pressure ; showing that as the arc is lengthened the resistance proper increases less rapidly when the pressure is reduced. The total equivalent resistance is, of course, greatly diminished by reduction of pressure, but this reduction seems to be wholly due to diminished conductive resistance, the inverse electromotive force for the arcs used, all of which were whistling ones, being even slightly greater than at normal pressure, so far as can be judged from the data at present obtained.

The scanty data at hand would not justify us, however, in concluding this apparent increase to be real. If such proves to be the case, the action is probably of the same nature as that supposed by Edlund to exist in the discharge of electricity in ordinary vacuum tubes ; that is, an increase in the opposition offered to the passage of electricity from the solid electrodes, as the pressure of the intervening gaseous medium is diminished. Further experiment, extending to higher vacua, and also with increased density is necessary, before any definite conclusions can be drawn as to this point.

In addition to those facts which are commonly recognized, the following conclusions seem to be justified by our experiments.

1. There is a definite inverse electromotive force for the whistling arc, whose value is approximately 15 volts.

2. The inverse electromotive force for both the silent and whistling arcs diminishes slowly as the current increases.

3. The inverse electromotive force, at least for the whistling arc, is less for the inverted than for the upright arc.

4. The great change in equivalent resistance which occurs when volatile salts are introduced into the arc, is chiefly due to a large fall in the inverse electromotive force, although there is at the same time a marked diminution in the conductive resistance.

5. The diminished total resistance of the arc in rarefied air, is due solely to a diminution in the conductive resistance.

6. There is some evidence to show that with considerable reduction of pressure, there is a slight increase in the inverse electromotive force.

ROGERS LABORATORY OF PHYSICS,
June, 1886.

DYNAMIC ELECTRICITY.

BY CARL HERING.

(Continued from page 303.)

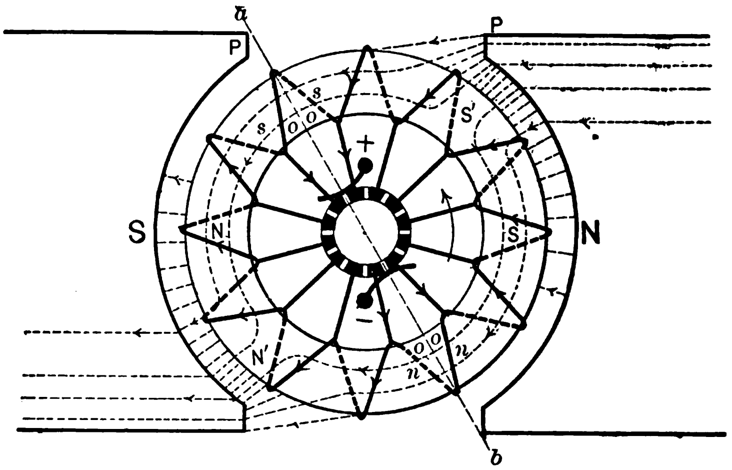
CHAPTER V.

ARMATURES.

THE foregoing chapter having completed the short review of the general and leading principles involved in the generation of electrical energy by machines, the remaining chapters will be devoted to a discussion of the practical application of those principles to the construction of machines, together with practical rules and hints in regard to the proportioning of parts, both of armatures and of the field magnets. As almost all of the machines built in this country use either the Gramme or cylinder armatures, or variations of them, such as the Thomson-Houston or Brush, the discussion on armatures will be limited to these general types. Both of these forms being very similar in many respects, and the first being the simplest in form, the first part of the present chapter will be limited to the Gramme type; the subject of cylinder armatures will be confined merely to the differences between it and the Gramme.

In order to appreciate more fully the reasons for many of the practical rules for constructing armatures, let us examine in detail what takes place in a Gramme armature while running. In figure 8 is shown a diagrammatic representation of a simple Gramme armature with its collector, brushes and pole pieces, the directions of the currents and lines of force being represented by arrows, as they would

Fig. 8



be while the machine is running in the direction indicated, the polarity of the pole pieces being as represented.

The direction of the currents may be determined by the practical rule given in chapter iii. By grasping the north pole piece in the right hand, the middle finger, which points down, will indicate the direction of the current if the wires between the armature core and the north pole piece were moving in the direction in which the thumb points, which in this case would be like the hands of a watch. As it turns in the opposite direction, however, the currents will also be in the opposite direction, which in this case will be from below up, thus giving the direction around the end of the armature as indicated. A similar application of the rule will show the direction of the currents at the south pole piece to be as indicated there, namely opposite to those at the north pole in the cylindrical portion of the armature, but in the same direction at the end of the armature, as will be seen in the figure.

From this the practical rule of thumb follows, for determining the direction of the currents in all types of Gramme as well as cylinder armatures, viz.: in looking at the commutator end of the armature, *if the rotation is opposite to that of the hands of a watch, the currents at that end will have the same direction as the lines of force,* namely from the north to the south pole pieces. In following one of these currents to the brushes their polarity may be readily determined. This polarity of the brushes will evidently be different, depending on whether the general direction of the windings of the armature is a right hand or a left hand spiral, which can readily be determined by following a wire from one commutator strip to the next. If a correct drawing has been made of a machine, on which the polarity of the pole pieces, the direction of rotation, and the general direction of the spiral winding in the armature, are indicated, the polarity of the brushes and the binding posts, can evidently be

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determined before the machine is built, provided the machine is constructed as designed.

All the small electromotive forces induced in each of the windings of the wire around the armature core, will, from the nature of the continuous winding, be added in series, and therefore at the brushes the total electromotive force will be the sum of all the smaller ones on one-half of the armature, as explained in the last chapter. Supposing the electromotive force induced in each winding to be the same, the practical rule follows that the electromotive force of a machine is proportional to the number of windings on the armature; and it is equal to that induced in one winding multiplied by the total number of windings divided by two, as the two-halves of the armature windings are in multiple arc.

The pole pieces will induce a north and a south pole in those parts of the iron core of the armature directly adjoining them, as shown at the letters S and N on the core. If this were the only magnetization of the core the lines of force would take the shortest direction through the armature core, and the line of the brushes *a b*, or diameter of commutation, as it is called, would be perpendicular to the magnetic axis of the pole pieces. In examining the magnetic effect of the currents in the armature wire, it will be seen that these currents also magnetize the core, in each half of which they tend to make two opposite poles, thus making a separate magnet of each half of the core, with north poles at *nn* and south poles at *ss*, as will be seen if the core is imagined to be cut into two parts through the line of the brushes *a b*, and the magnetic polarity determined at each end. These two independent magnetizations, one by the pole pieces and the other by the armature current, will tend to oppose each other to a certain extent, and will produce resultant poles at N′ S′. These will be the real effective poles in the induction and the lines of force will, therefore, be crowded to one corner of each pole piece, as shown in dotted lines, some of which are shown as they pass through the armature core. As the line of the brushes, *a b* (that is, the line through the two points where the currents induced in the two halves of the armature, meet), will be perpendicular, or nearly so, to this line of magnetization, it follows that the brushes will have to be shifted in the direction of rotation.

This shifting of the brushes is often erroneously attributed entirely to the so-called magnetic lag, which is the tendency of the iron core to retard its magnetization when entering the field, and to retard its demagnetization when leaving it. Although this is the case to a slight extent, it is, in a soft iron, laminated armature, very small as compared to the transverse magnetization by the armature current. It is very easy to determine how much of this displacement of the brushes is due to the magnetic lag, by finding the position of the brushes at which the greatest potential exists when the machine is running on open circuit, that is, without a current in the armature, in which case the magnets must be excited by another machine. This amount of displacement is then evidently due entirely to the magnetic lag, provided the armature is perfectly balanced electrically.

The shifting of the line of the brushes, when the armature is generating current, will be greater in proportion to the magnetization due to the armature coils, that is, in proportion to the number of windings on the armature; as its effect is very objectionable, because it practically makes the effective pole pieces narrow, causes bad sparking, etc., the important rule becomes evident, viz.: make the number of windings on the armature as small as possible, and therefore the other two factors on which the electromotive force depends, namely the speed and the field, should be made correspondingly great. There are, also, other reasons for this same important rule, which will be mentioned below. It is one of the most important rules in the construction of a well proportioned machine. In several cases in the writer's experience the capacity of a machine, in lamps, was doubled without any increase of size of the frame, by a proper application of this rule.

If one of the brushes were to leave a commutator strip before it touches the next, the circuit would be momentarily broken at that instant, which would result in forming a succession of small arcs. This is generally termed sparking, and is very injurious, as it burns off the brushes and the commutator bars. It is, therefore, absolutely essential that a brush should bridge over the insulation between two commutator bars and touch one bar before it leaves the other, as shown in figure 8.

From the nature of an armature winding, two neighboring commutator strips represent the two ends of one of the coils of the armature, and it therefore follows that while a brush touches two strips, that coil which terminates at those two strips, is short circuited through the brushes, as shown in the two coils marked *o o*. This current represents a certain amount of loss, as it does not appear in the external circuit. When the brush leaves a commutator strip, after having short circuited this coil, this local current is broken at the terminal of the brush, and therefore causes sparking. This is, perhaps, one of the chief among the many causes of sparking, and should therefore not be overlooked. As this short circuiting cannot be avoided in the ordinary form of commutator, the only thing that can be done is to make the current in that coil as small as possible. It may be argued that the induced electromotive force in this coil is always small, but it must also be remembered that it is short circuited by a very low resistance and that the current may therefore be very great. For instance, if the induced electromotive force in that coil be only .1 volt and the resistance of that one coil .001 ohm, the local current would evidently be 100 ampères by Ohm's law, and when a current of 100 ampères is suddenly broken a spark will be produced, especially as the current flows through a coil which has self induction, the action of which is to tend to prolong the duration of the spark or arc, by suddenly increasing its potential.

The only way to reduce this objectionable current is to make the induction in that coil as small as possible and to decrease its self induction. The coil should, therefore, always lie near the neutral point in the field, and should be in the weakest part of it; it should, moreover, move in the direction of the lines of force so that there is little or no induction in it.

The ends of the opposite pole pieces, P P, nearest each other should, therefore, be as far apart as practicable, so that as few lines of force as possible pass directly from one to the other through these two short circuited coils. A good rule is to make this distance, P P, at least eight times the distance between the iron of the pole pieces and the iron armature core. It should even be more if practicable, but not less. From this it also follows that the distance from the pole piece to the armature core, or in other words the depth of the windings on the armature, should be as small as practicable. To keep the short circuited coil in the weakest part of the field the diameter of commutator, or line of brushes, should be shifted as little as possible from the position normal to the line joining the pole pieces, in the case of a Gramme armature. This is another reason for making the armature windings as few as possible, as stated above. The field should be balanced, that is, it should be symmetrical both magnetically and in the outline of the iron parts, in order that not only the brushes but also the short circuited coils should be exactly diametrically opposite. The brushes should not short circuit more than one coil, and should therefore not touch more than two strips at any time; neither should there be two brushes on each side, the distance between which is greater than the width of a commutator strip, as they would then short circuit more than one coil. Finally, to decrease the self induction of these short circuited coils, the number of windings per coil should be as small as possible and

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consequently the important rule that the number of coils or number of commutator strips should be as great as possible to diminish the number of windings per coil. As the self induction increases with the square of the number of windings in the coil, halving this number by doubling the number of coils or commutator strips will diminish the self-induction in the short circuited coil to one-fourth of what it was before.

As the direction in which the currents tend to be induced in all the coils of the armature depends only on the polarity of the pole pieces and the direction of rotation, it is independent of the position of the brushes. From this it will be seen that if the brushes are moved to different parts of the circumference of the commutator the direction in which the current will have to flow in some of the coils will be opposed to that induced in them, and therefore the electromotive force of these opposing coils will be subtracted from the rest and the difference will appear at the brushes. This is often made use of to regulate the electromotive force of a machine. It is similar to regulating the difference of potential of a set of accumulators, by connecting one or more so as to oppose the others. The difference in the amounts of energy at the poles is therefore not wasted, but is stored up again in the few cells which oppose the others; or in the case of a dynamo the current in the opposing coils tends to make it a motor. This method of regulating is therefore in that sense not uneconomical, but it has the very serious objection that as the brushes are shifted to different parts of the commutator, the coils which are short circuited by them are no longer in a weak neutral field but have considerable electromotive force generated in them, and therefore the current circulating in them when short circuited by a brush will be very great, and the armature will therefore heat, waste energy, and spark badly at the commutator the more the brushes are moved from their proper position. Unless some device is used for blowing out these sparks, as in the Thomson-Houston machine, such regulation should not be used in well built machines except within very small limits.

When two brushes are used on each side of the commutator, both leading to one terminal, the coils lying between them are necessarily short circuited by them, and if there is the slightest induction in these coils there will be a local current flowing through them, which heats the armature, wastes energy and causes bad sparking.

Another cause of sparking is the self induction of the coils in the armature. This is similar to inertia in mechanics, and is that quality of the coils by virtue of which they resist the starting or stopping of a current through them. It acts every time a brush makes, or breaks contact with the next commutator strip, as this starts or stops a current in the corresponding coil. As this self induction is proportional to the square of the number of windings in the coil, the same important rule follows that the number of windings on the armature should be as small as possible, and for a given number of such windings, each coil should have as few as possible by making the number of coils or commutator strips correspondingly great.

It will be seen from figure 8 that the wires of two neighboring coils never have a greater difference of potential in them than that generated in one or two coils. For instance, if there were 64 coils and the machine gave 64 volts, it is evident that each coil generated on the average about two volts, as 32 coils are connected in series. Two volts, or at most four volts, is the greatest potential in any two neighboring wires. There is, therefore, no likelihood of the current "jumping" from one to the other, which is the reason why the Gramme armature is especially well adapted for high potentials. This is a characteristic and important difference between it and the cylinder armature, in which the whole difference of potential can exist between two neighboring wires, as will be explained later. In all armatures it is important to insulate, very carefully, the wires from the core, for if this insulation should be crushed or should rub through at one point, the whole electromotive force of the machine will act at another point to burst through the insulation and cause the current to "jump" through to the core, thus burning out the armature. This is the most frequent cause of armatures burning out; an armature should not be used in which any one point of the wire touches the iron core. The core should have all corners and edges rounded; it should have no sharp ridges, or burrs produced while turning it in the lathe, and above all there should be no loose parts which may rub against the wire, and no parts which can get loose when the armature expands on being heated.

As the two halves of the armature winding are in multiple arc, it is very necessary to have the electromotive forces induced in each half equal to each other. For suppose there was a difference of one volt, it is evident that when the machine is running on open circuit there will be a wasted local current circulating through the armature wire, which will be approximately equal to one volt divided by the resistance of the two halves of the armature wire in series. If this were .01 ohm, this local current circulating in the armature would be almost 100 ampères, the self induction tending to reduce it somewhat. This local current becomes less as the current in the external circuit increases. It is, therefore, very important to have the same number of turns in all the armature coils, to have them all symmetrically situated with respect to the field and the axis, and to have a balanced field.

This is especially important in a cylindrical armature, which is often less symmetrical than the Gramme. If the two electromotive forces were not equal, the armature would be like two batteries having unequal electromotive forces and connected in multiple arc, in which case the stronger would evidently charge the weaker on open circuit.

In regard to the magnetism of the armature and the distribution of the iron, the following are among the most important rules to be guided by. As the space between the pole piece and the core of the armature is composed of the non-magnetic materials, air and copper, it offers the greatest resistance which the lines of force have to pass through, in their magnetic circuit. This space should therefore be as thin as possible measured radially to the armature or in the direction of the lines of force; it should also have as large a surface as possible measured on the cylindrical surface of the armature, which is the same as the active surface of the armature. By reducing the thickness of this space by one-half, it does not follow as is sometimes supposed, that the magnetism will be four times as great, as the well-known rule that the magnetic intensity varies inversely, as the square of the distance does not apply to the distance between the two neighboring surfaces of two large magnets. Although the magnetism does not increase inversely as the square of this distance, yet it is increased very much by reducing this distance between the armature core and the pole pieces. It therefore follows from this also, that the number of windings in the armature should be made as small as possible to reduce this thickness; also that the thickness of the copper wire should not be greater than is necessary to carry the current without heating too much. The diameter of the armature core should be as large as practicable, and its length, or the length of the pole pieces, should be as great as practicable, in order to increase the area of this non-magnetic space.

Prof. S. P. Thompson has made some experiments[1] designed to show that by placing iron ridges or partitions between the armature coils extending from the iron core to near the pole pieces, the electromotive force will be considerably greater. As the number of windings and the speed in this experiment were the same in both cases, it

1. Dynamo-Electric Machinery; pages 66-69.

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follows that the magnetism must have been thereby increased. The iron projections or lugs as shown in his illustration were very large and massive, and it is therefore a question whether the increased effect was due to the increased amount of iron or to the different shape, as it is possible that his Gramme armature core was over saturated. It is also a question whether the electromotive force would not be increased by omitting these lugs and filling the space occupied by them with some additional windings on the armature. This could readily be proved by a simple experiment.

The lines of force pass through the cores of the magnets, the pole pieces, and thence through the armature core as shown in figure 8. The most economical cross section of these parts is, as explained before, that at which the iron is just saturated. Supposing that the field magnet cores have been so proportioned, the cross section of the armature core can then readily be calculated. For instance, if there are four magnets, as in the Weston type of frame, the iron ring of the Gramme armature should evidently have a cross section equal to that of one field magnet core; for as many lines of force pass through one half of the ring as through one field magnet core, as will be shown in discussing field magnets. This supposes the quality of the iron to be the same in both. As the field magnets are generally cast iron, while the armature core is wrought iron, its cross section would need to be only about two-thirds as great. On the other hand, the armature core is not solid but is generally laminated or made of wire, so that if the outside cross section of the core when completed is taken, it should be made greater than ⅔ by the amount of the non-magnetic space between the laminæ.

The so-called Foucault currents in an armature core are nothing more than currents which are induced according to the same laws, and in the same direction as the useful currents in the copper wire, only that they are induced in the iron where they cannot be used; for it is evident that induction will take place in any moving metallic parts of the armature which cut lines of force, whether these parts be copper conductors or masses of iron forming the magnetic core. It will be seen from this that the Foucault currents tend to flow in the core under the windings, in the same direction as the useful currents, that is, parallel to the axis, and in two opposite directions on the two sides. They are most intense in the outer portions of the core, as the speed and number of lines of force cut are greatest there. By omitting the core and winding a Gramme armature entirely of coils of iron wire, connecting them to the commutator as usual, the Foucault currents then become the useful currents and will be the only currents induced. In this case the iron wire coils act at the same time as a magnetic core, and as conductors of the current. As the resistance of iron wire is so high, this method does not appear to have been a success in practice. It is given here merely as an illustration of the nature of Foucault currents.

As with the useful currents, the Foucault currents are the result of an induced electromotive force equalizing itself through a certain resistance. To prevent these currents from being generated it is necessary either to prevent the induction of the electromotive force, or to prevent the electromotive force from equalizing itself by making the resistance infinitely great. The former is impracticable, for the only way to prevent the induction of electromotive force in the core is either to keep the core fixed in position so as not to cut lines of force, or else to omit the core altogether or make it of wood or some other non-conductor. The only practical way, therefore, to avoid the generation of the currents is to make the resistance very great by laminating or otherwise dividing the iron core into a large number of small insulated parts. As the direction of these currents is the same as that in the copper wires, this lamination must be perpendicular to the copper wires, that is perpendicular to the axis. An armature core should therefore be made of discs, rings, or wires in planes perpendicular to the axis, and insulated from each other so as to prevent currents from flowing parallel to the axis or the copper conductors. The induction of small electromotive forces will nevertheless take place in each disc, but they will not be connected in series and cannot produce currents; they will therefore not consume energy, nor heat the core, as energy is electromotive force multiplied by current. The discs should be as thin as possible, for if they are too thick the unequal induced electromotive forces in different parts, which are moving at different speeds, will cause currents to circulate in each disc.

The cores should be made of the softest wrought iron, to diminish the amount of magnetic lag mentioned before. In well proportioned and well designed machines they should never be made of cast iron, even if it is cast massive, and then cut so as to be a substitute for laminæ. Cast iron has a lower saturation point than wrought iron, therefore cores of cast iron require a larger bulk of iron, than when made of wrought iron. This, at the same time, will increase the length and, therefore, the resistance of the copper wire, thereby decreasing the efficiency of the machines. A core of a Gramme or cylinder armature should under no circumstances be solid iron.

If the laminæ are to be made of rolled wrought iron, it will generally be found that the iron sheets are coated with a thin layer of blue oxide. This is very hard and acts to retard the magnetization and demagnetization. This should be removed, which can readily be done by immersing the discs for a short time in dilute sulphuric or hydrochloric acid (about 1 to 10), after which they should be washed very thoroughly in water, and preferably immersed in a bath containing soda or potash, otherwise the acid will rust them badly after the armature is made.

In order to see whether this blue oxide retarded the demagnetization, the writer made the following experiment: Several discs were taken from the same lot; some of them were cleaned as described, while the others were left with the coating of blue oxide on them. They were fastened together and magnetized very strongly in one direction, all being magnetized to the same degree. After this they were examined for magnetism, and it was found that the clean ones had very little residual magnetism, while the others showed strong magnetic polarity.

(To be continued.)

THE WESTINGHOUSE ELECTRIC LIGHT PLANT AT TRENTON, N. J.

The incandescent light plant recently installed by the Westinghouse Electric Company, at Trenton, is so good an example of excellence and completeness, in both design and execution, that we have, as announced in our last issue, prepared some description of it with illustrations.

The plant is laid out for 2,400 lamps. It was started in operation July 1st with about 500, and is now running 1800 lamps, distributed chiefly in places of business in the central part of the city.

The plan of distribution employed is the three-wire system of Mr. H. M. Byllesby—now general manager of the Westinghouse Electric Company. A cleverly arranged switch at the central station, operated by a single movement of a lever, changes the whole system to that of the ordinary multiple-arc or two-wire distribution. (See diagram on page 339.)

The central station, located in the interior of a block in the business part of the city, is substantially built of brick. It is 30 by 25 feet wide, in two stories, with an extension for boiler room. The lower story is wholly given to the steam plant, the upper floor to the electric machinery. The steam plant includes a battery of three

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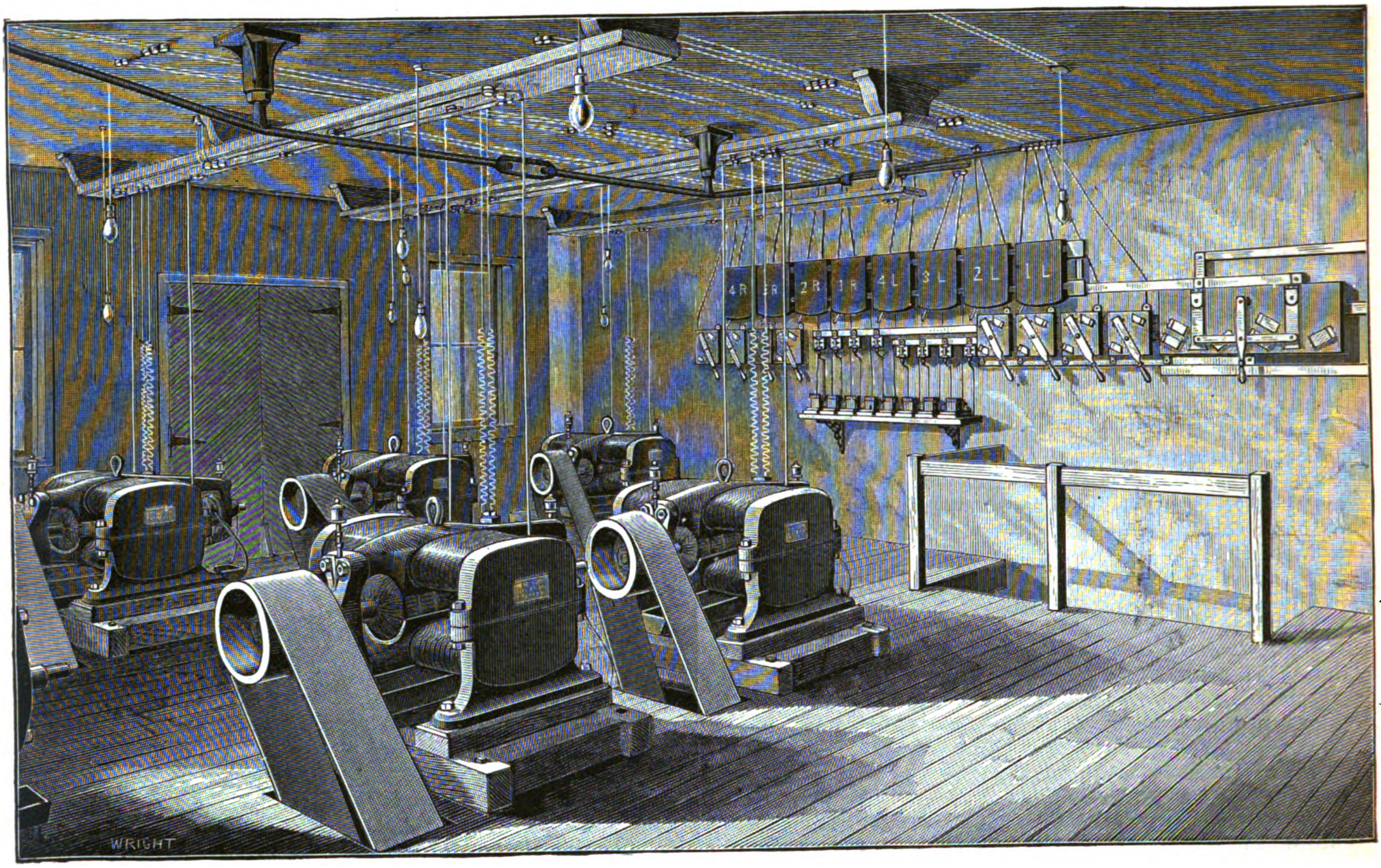
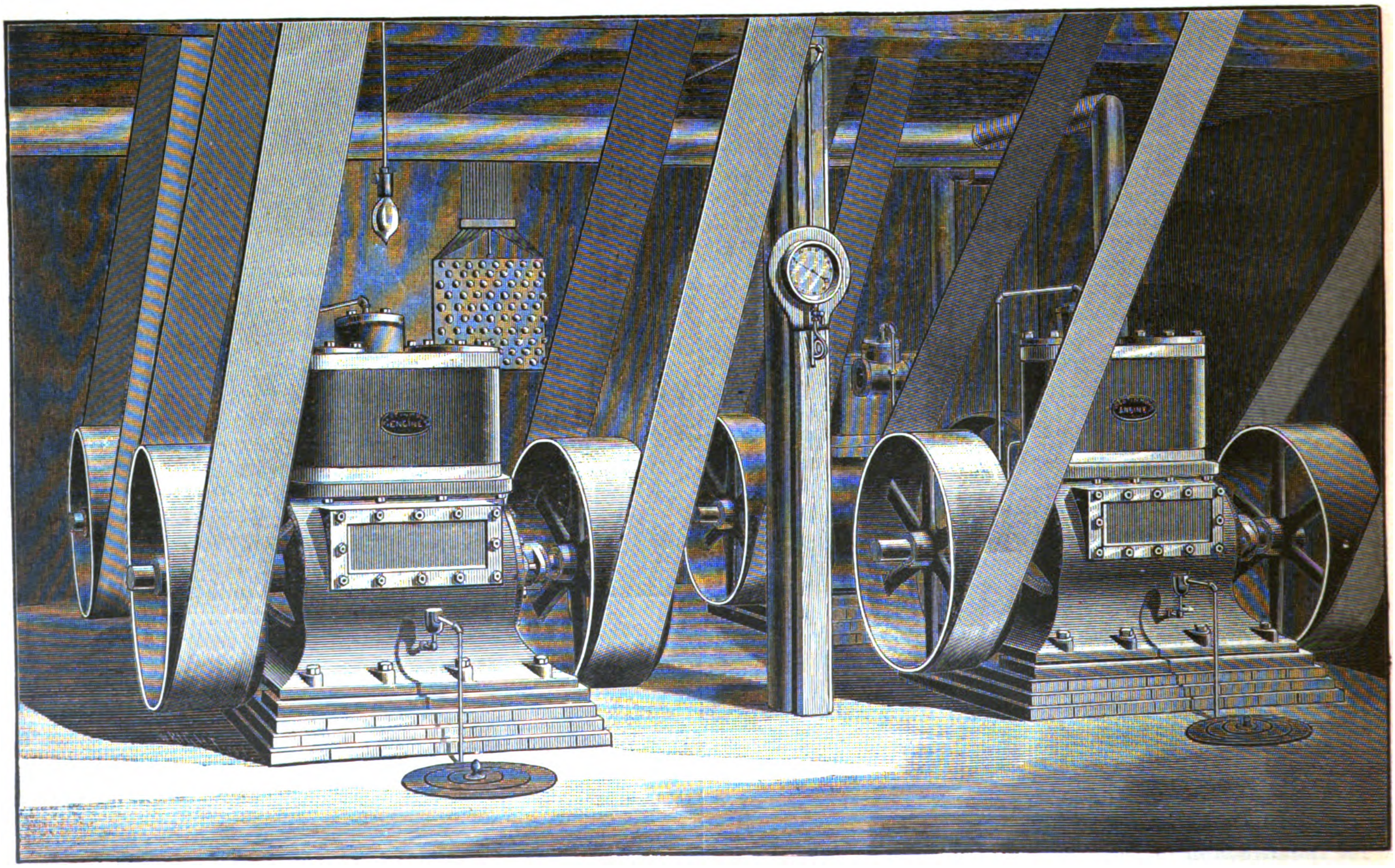


DYNAMO ROOM OF THE TRENTON ELECTRIC LIGHT STATION.—WESTINGHOUSE SYSTEM.



ENGINE ROOM OF THE TRENTON ELECTRIC LIGHT STATION.—WESTINGHOUSE SYSTEM.

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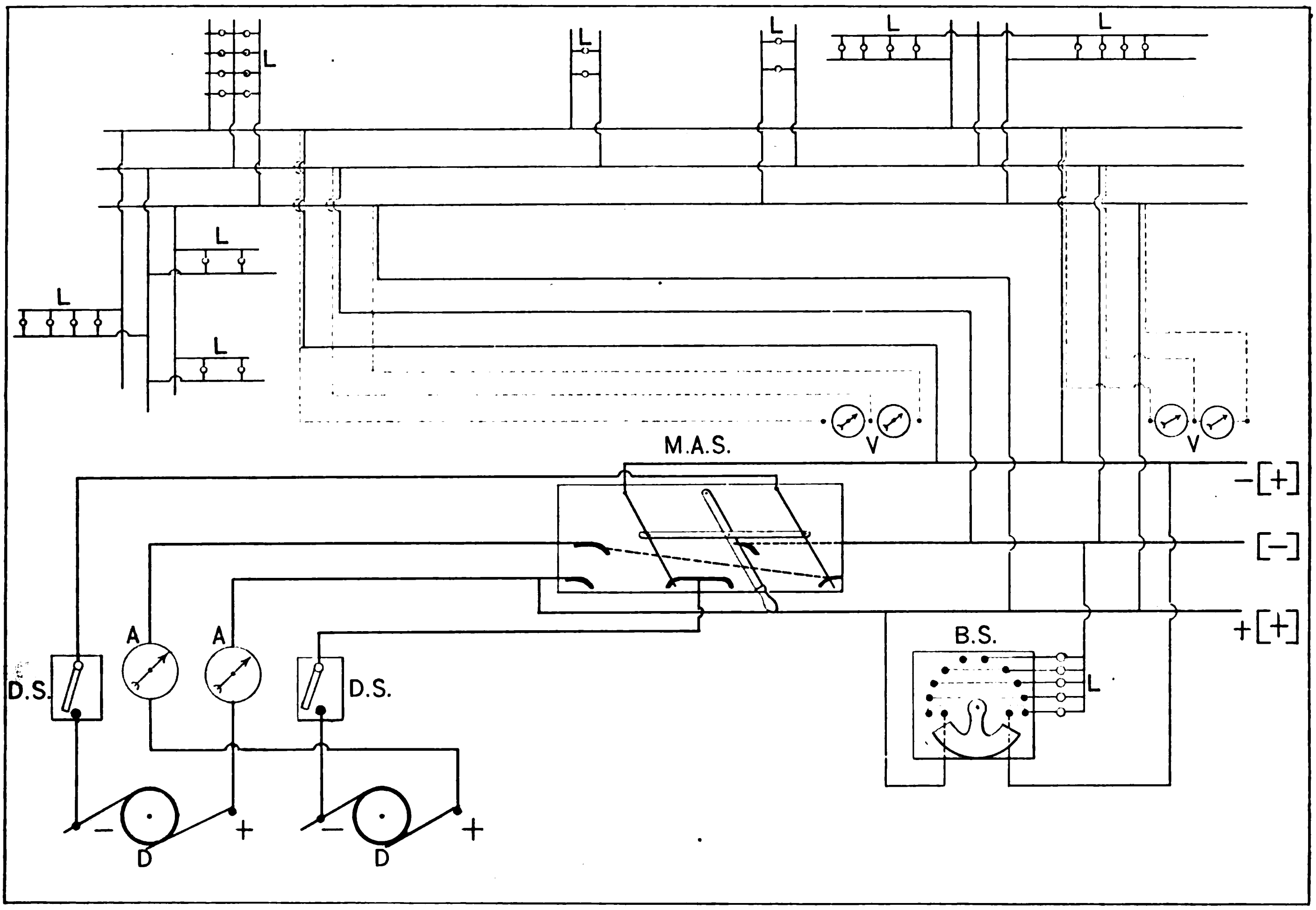
steel tubular boilers, made of single sheets of steel, having no circular seams, with Ashcroft shaking grates, set 42 inches from boiler surface, and four Westinghouse engines of 75 rated horse-power each, with steam pumps and feed-water heater. Each engine has two fly wheels belted to the dynamos through openings in the ceiling and floor above. This two-story arrangement of building is economical of ground space. Eight dynamos, of 300 16 c. p. light capacity each, are mounted on the floor of the second story, the accessory electrical apparatus being distributed upon the walls of two sides of the room.

The illustrations on page 338 show the arrangement of the engine room and dynamo room.

On entering these rooms a visitor is at once impressed by the complete and substantial character of the whole outfit, as well as by the symmetrical and convenient arrangement of the machinery and appurtenances. The B S the balancing switch, V the voltmeters and L the lamps. An ammeter is in circuit with each dynamo. The voltmeters, arranged in pairs, are connected by special wires to the mains at distant points, and, as will be seen by inspection of the diagram, are so joined up as to show any variation in the electromotive force between the positive and negative mains, and also any departure from exact equality in its distribution arising from turning on or shutting off lamps on either side of the neutral wire. Any such variation is corrected at once by means of the balancing switch, which is arranged to throw as many extra lamps as required into circuit on either the positive or negative side to preserve equilibrium. In wiring premises of subscribers care is taken to distribute lamps equally on either side of the neutral wire, to preserve as nearly as possible a normal balance for the three-wire system.

The positive and negative signs, bracketed in the dia-



THEORETICAL DIAGRAM OF THE TRENTON PLANT OF THE WESTINGHOUSE ELECTRIC COMPANY.

interior connections from the fusible cut-outs to the balancing switch (see illustrations on page 338 and theoretical diagram) are copper strips 2 inches by ½ inch; thence to cupola of No. 00 copper wire. All the interior wiring of the central station is plainly in sight and easily accessible.

The theoretical diagram above, shows the system of wiring and interior connection. Only two of the eight dynamos are shown in the diagram, as they serve to exhibit the system fully. With the entire plant in operation the eight dynamos would be connected in two multiple arc groups of four each, joined in series for the three-wire system, or in one group of eight in multiple arc for the two-wire or multiple-arc system.

Referring to the diagram, D designates the dynamos, D S the dynamo cut-outs, A the ammeters, M A S the multiple-arc switch for interchanging the systems of circuit; gram, indicate the distribution of electromotive force when the circuits are switched over to the multiple-arc or two-wire system. This is only done when the work is light, as after midnight, or at other hours when few lamps are in use. On the occasion of our visit, when some 900 lamps were in use, the multiple-arc switch was turned back and forth, causing no sensible interruption of light, merely a slight flicker.

Every detail of the outfit seems to have been carefully planned and carried out. The result is a station thoroughly equipped for its work, and handsome to look upon. The Westinghouse Electric Company, and Messrs. Westinghouse, Church, Kerr & Co., of New York, are to be congratulated on so good a piece of work.

The Trenton plant is owned and operated by The People's Electric Light Co., which also operates a Brush

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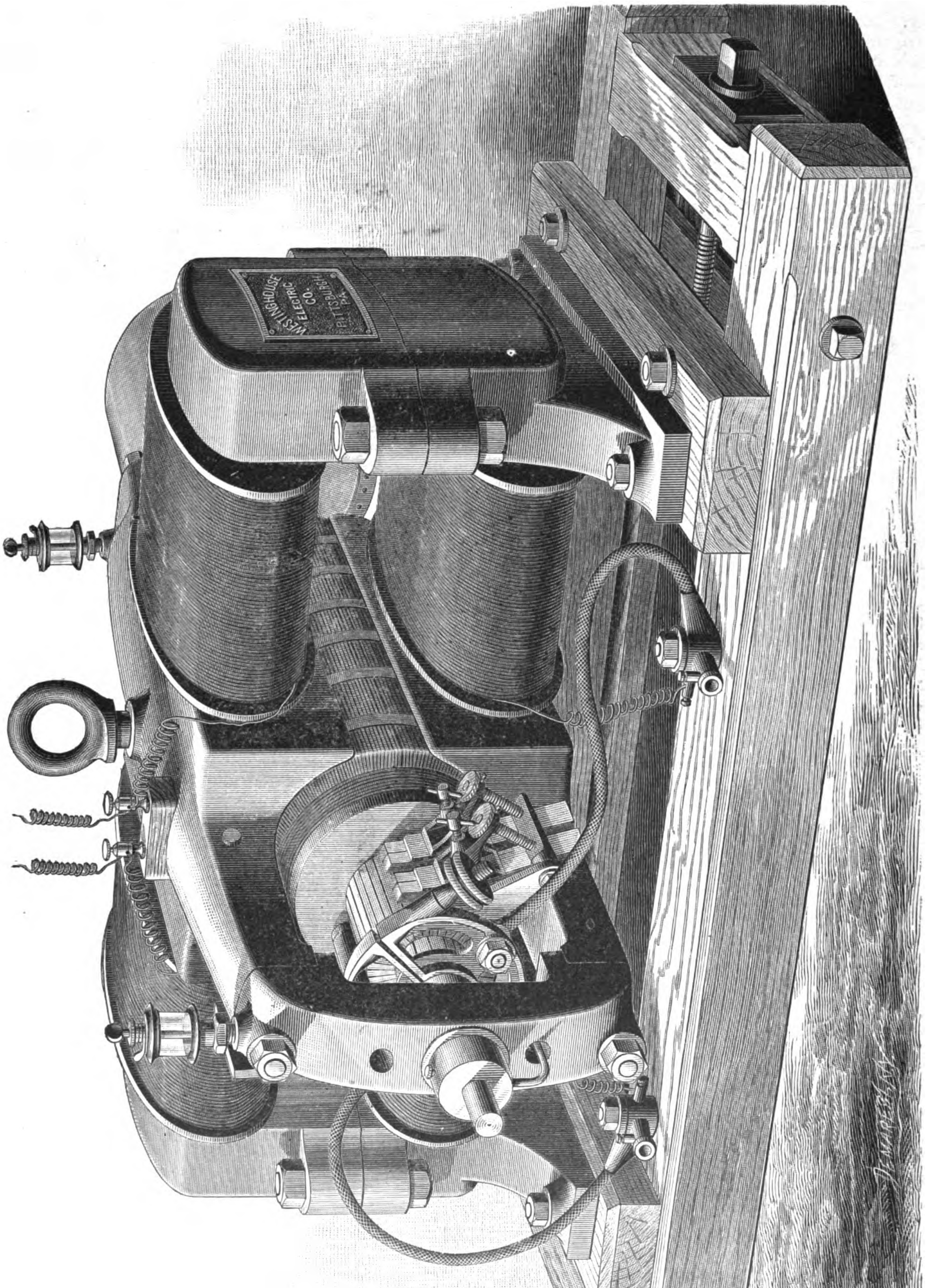
arc station of 100 lights, and is under the superintendence of Mr. Charles J. Young, late superintendent of the Edison station, at Newburg, N. Y.



THE WESTINGHOUSE DYNAMO.

The light service is excellent, meeting with such popular favor that the subscriptions now exceed the capacity of the plant as designed. Early preparations will be made for its enlargement. It is confidently expected that the demand for domestic service will be considerable.

The establishment of plants of this character, so complete and business-like in appointments and effective in management, augurs well for the future of electric lighting.

In addition to illustrations pertaining to the Trenton

outfit, we print cuts of the Westinghouse dynamo and lamp.

Mr. Van Wagenen, of the Westinghouse Electric Co.,

has been in charge of installing the plant and its initial operation.

METHOD OF ADJUSTING TANGENT GALVANOMETERS.

The following convenient method of adjusting a tangent galvanometer is contributed to the London *Electrical Review* by W. Moon.

Take two deflections, with the same current, one on each side of the scale. Let d be greater than d_1. Then

$$\frac{\sin. (d - \delta)}{\cos. d} = \frac{\sin. (d_1 + \delta)}{\cos. d_1}$$

where δ is the angle the coils form with the magnet.

$$\therefore \frac{\sin. d \cos. \delta - \sin. \delta \cos. d}{\cos. d}$$

$$= \frac{\sin. d_1 \cos. \delta + \sin. \delta \cos. d_1}{\cos. d_1}$$

$$\therefore \tan. \delta = \frac{\tan d - \tan. d_1}{2}$$

Now let the instrument be turned through the angle $\delta = \tan.^{-1} \left(\frac{\tan. d - \tan. d_1}{2}\right)$ in the direction of the smaller deflection. Then adjust the pointer until it points to zero again. If the scale of the instrument is movable the adjustment may be made by turning the scale through the angle, δ, in the direction of the greater deflection instead of bending the pointer.

THE PRINCIPLES OF SECONDARY BATTERY CONSTRUCTION.

I.

Up to very recently, the tendency of most secondary batteries, unfortunately too frequently, was to go wrong; and necessary as these instruments are to the development of electric lighting, especially for domestic purposes, it must be admitted that they do not as yet enjoy full public confidence. Very great improvements have from time to time been made, and batteries can now be obtained which are almost perfect. But they are expensive, and have still some defects. It will be our aim in the present paper to point out what these defects are, how some may be remedied, how others are corrected, and the probable direction in which we may expect they may all be avoided.

Early in the present century, Ritter discovered that the platinum electrodes of a voltameter were capable of returning a current in a direction reverse to that of the original battery, and, therefore, opposing it. These currents were, however, of but short duration; and it was not until Planté, in his careful and elaborate work, "Recherches sur l'Electricité," pointed out the method by which currents of much greater duration could be obtained, that the attention of scientific men was seriously drawn to the practical importance these secondary cells might possess. Planté's discovery was, however, in advance of his times; the costly methods of obtaining electricity in any large quantity, and the long, tedious electrical process required in the formation of his cells, militated very much against his secondary batteries coming into successful operation. Nevertheless, with true scientific ardor, he devoted himself to his investigations, published from time to time the results he had attained, and, to-day, in the light of our later knowledge, one cannot help being struck at the minuteness and care displayed in his observations. To the outside world, however, little was known of these secondary cells; they are but briefly alluded to in the text-books, and the literature concerning them beyond Planté's work is of the barest possible description. Even now, after the years of patient labor given by Faure, Swan, Sellon, Volckmar, and a host of others, we look in vain for the work that tells the tale, or gives any adequate account of one-fiftieth part of the labor spent in the endeavor to perfect them.

The Planté battery consists essentially of two plates of lead, kept apart by bands or rolls of gutta-percha, and immersed in dilute sulphuric acid. These plates, after having been connected to a couple of Grove or Bunsen cells for a short time, are capable of returning a current of considerable strength, but of exceedingly limited duration. It was noticed after a while that the cells improved with age, and that the return currents remained constant longer than when the cells were new. An investigation resulted in the method of "forming" the plates so that they became able to receive a heavy charge. This process, as described by Planté, is as follows:

The first day the cell is charged in alternate directions some five or six times, for periods gradually increasing from a quarter of an hour to one hour, and discharged between each charge. It was found that the discharge to be obtained after each primary charge was of greater duration up to a certain time; when there appeared to be no gain in capacity. The cell was now allowed to remain charged in the negative direction, *i.e.*, in the direction opposite to the

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original charge for some hours. Next day these operations were repeated, but the time of charging was prolonged, each charge now lasting two to three hours. Again a period is reached in which no appreciable gain in capacity can be noticed. The cells are now allowed to remain charged in the negative direction for a week, and again reversed. Periods of rest next intervene, and are gradually increased from a fortnight, then a month, two months, and so on; after each period of rest, the capacity upon subsequent charging being largely increased. To what is this increase due, and why do we obtain any return currents at all? To answer these questions satisfactorily, we must turn aside for a while, and consider the theory of the action that goes on in any voltaic cell. We must all along bear in mind that there is no important difference between a primary and secondary battery when we are discussing either as producing current, and if we mention in the course of our remarks a Daniell or a Smee, the theory applies with equal force to the action going on in a Planté, a Faure, or even the later modifications of these arrangements.

The production of a current of electricity in a voltaic battery is invariably accompanied by chemical actions in the cell, and chemists have consequently, owing to the peculiar nature of all combinations, long been accustomed to divide all elements, or, perhaps, more properly speaking, all combinations of atoms capable of being added to or taken from another combination of atoms as a group, into two great classes, which they have designated electro-positive or basylous, and electro-negative or chlorous. Thus we find that hydrogen, potassium, silver, copper, and all the metals are termed electro-positive, whilst oxygen, chlorine, iodine, bromide and nitrogen are classed amongst the electro-negative.

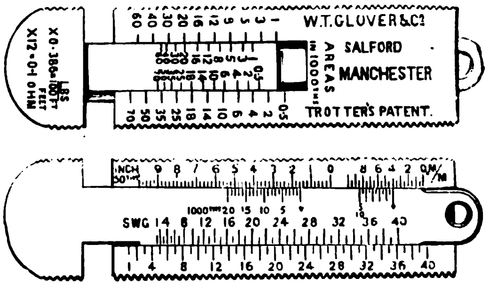
Further, according to the Clausius modification of the Grotthuss theory, we have to imagine that in liquids these groups of atoms, or radicles, as they are called, are in a continual state of movement, wandering to and fro, sometimes entering into new combinations with each other, sometimes even their component atoms seeking and obtaining a decree *nisi*, so that they may combine with other atoms. These groups, however complex they may appear, always combine in a certain order, and have, consequently, been further divided into classes, termed monad, dyad, triad, and so forth. Now, Faraday has shown that each dissociated monad radicle possesses a certain definite quantity of electrical charge, and that this charge is precisely the same in quantity no matter what the monad radicle may be. Dyads and triads have twice and thrice this charge respectively. These charges, although precisely the same in quantity, may differ in sign; hence the distinction which chemists have drawn between electro-positive and electro-negative elements.

If, then, we placed two electrodes oppositely charged in a liquid containing these dissociated radicles, we should expect to find that in the immediate vicinity of these electrodes, the radicles that have negative charges would be drawn towards the positive electrode, and the electro-positive radicles attracted towards the negative. Suppose, then, we place two pieces of platinum foil in a liquid electrolyte which contains these wandering radicles (no liquid which does not contain these dissociated radicles can be an electrolyte), and keep the platinum foils in such permanent connection with a battery that one remains continuously positive and the other negative; and if we further consider, for the sake of simplicity, that the dissociated radicles are the electro-negative oxygen and the electro-positive hydrogen, we should observe, if our expectations be well grounded, that the positively-charged electrode will attract the negative O, and the negative electrode the positive H. This is the case: the oxygen atoms glide towards the positive electrode, give up their charges to it, and, uniting with each other, float off to the surface as bubbles of gas. On the opposite side, the hydrogen atoms turn towards the negative electrode, give it their positive charge, and in turn they, too, rise to the surface as gas. Be it noted now that each electrode, whilst in the liquid, is collecting charges of electricity opposite in sign to the permanent charge it receives from the outside source. It is not difficult to imagine that these charges might become powerful enough to overcome and repel the charge from the extraneous source, unless we took proper precautions that this charge is kept up to its original strength.—*Industries.*

STANDARD WIRE GAUGE.

A NEW wire gauge, based on the English standard sizes as fixed by the act of 1883, was brought out in England early in 1885. Some valuable improvements which have since been effected in it render it of much greater value to electricians.

In its present form the gauge will register the legal number of any wire up to No. 1 (.300) S. W. G. (standard wire gauge); formerly it only read up to No. 6 (.192). In addition to this very valuable extension, the area scale, by which the current suitable for any size of copper wire can be calculated, has been enlarged; and whereas it only registered the areas in thousandths of a square inch up to .030 square inch, it now gives them up to .070. We illustrate this scale of areas and draw special attention to it, on account of its usefulness for calculations. In the first place, if the current be taken as 1,000 ampères to a square inch of copper, then this scale of areas may be taken as a scale of ampères direct, but if it be decided to transmit at the rate of 2,000 ampères to the square inch, then all that is



necessary is to multiply the area by 2. Again, if the area figures be multiplied by 0.4 (more accurately 0.0386), it will give the weight in pounds per 100 feet of the wire measured, while by multiplying the area by 12 we have the length in feet of copper wire having a resistance of one-tenth of an ohm. By multiplying the area figures by 0.323 we get Sir Wm. Thomson's rule of 0.5 ampère to a square millimetre. Again, multiplying by 0.0575 we get horse-power lost per mile with 1,000 ampères to the square inch. 42.8 divided by the area gives the resistances in ohms per mile, while the area multiplied by 20.35 = lbs. per mile. These considerations seem to point to this little instrument as one likely to supply a want of electricians generally, as anything that saves time and facilitates prompt and accurate calculations cannot be other than of the utmost value in these days of high pressure. We cannot but compliment the inventor, Mr. A. P. Trotter, as the gauge is both novel and useful. It has been brought out by Walter T. Glover & Co., Salford, Manchester, England. The gauge can be had from the Electrical Supply Co., New York.

AN INTERNATIONAL STANDARD WIRE GAUGE.

To elicit information on the much discussed, but never settled, subject of a standard wire gauge, the *Electrical World* recently addressed a letter to many large users and makers of wire throughout the country, asking their views in respect to the adaptation in this country of the new

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English standard gauge—particularly asking replies to two questions as follows :

1. What is your practice in ordering or manufacturing wire ?
2. Would you recommend federal or state legislation enforcing the "standard" gauge in contracts ?

Twenty-five replies are printed in the *Electrical World*, July 3 and 19.

An examination of them shows the following state of facts.

Among the manufacturers but one case of an order by the new gauge is reported, although it was adopted by the National Telephone Exchange Association in 1885, and by the Electric Light Association in February last.

The majority of the large users report that they order wire by diameters in mils, or by weight; of the others, more order by Brown and Sharpe's gauge than otherwise.

As to legislation, federal or state, the prevailing opinion is unfavorable, mostly upon the ground of its probable futility.

One correspondent reports the practice of ordering by both gauge number and diameter.

Most seem to agree that the present confusion of gauges is a practical inconvenience, and that any standard generally adopted and used by manufacturers and consumers would help all hands.

It seems reasonably clear that legislation could do but little to secure the general practical adoption of any gauge, and that the various systems of dimensions used in ordering and manufacturing wire will have to submit to the process of natural selection and the survival of the fittest.

ABSTRACTS AND EXTRACTS.

THE DECLINE IN COPPER.

The great Calumet and Hecla Company are in the habit of doing things in a sensational way, and about once in so often like to make their power felt by a change in prices which disturbs the conclusions of the entire trade. This week they have created a sensation in the trade by closing with leading consumers for two months' supply at 10c. The quantity included in these sales is said to be about 8,000,000 lbs. During the past two months influences have been at work which have tended to force the Calumet and Hecla company to lower their prices. Judging from the output reported thus far the make of the Lake Superior district this year will reach about 75,000,000 lbs. of ingot, though present prices may lead to some curtailment. At figures recently ruling, Arizona might have been counted upon to turn out between 20,000,000 and 23,000,000 lbs. Montana might be counted at about 60,000,000 to 65,000-000, and from scattering sources about 5,000,000 lbs. may be added. This would run the production, at 11c for Lake and 10c to 10½c for other brands, to about 160,000,000 to 168,000,000 lbs. Considering the fact that the current consumption is estimated to be at the rate of 100,000,000 lbs. approximately, there would be left for export about 60,000,000 to 68,000,000 lbs. Now the American market has been relatively higher than that abroad, and the tendency was to produce a contest between the miners of the different sections for this the better market. Formerly the product of Montana, where the greatest increase took place, went abroad almost entirely, but two causes contributed towards diverting a larger share into our channels of trade. Formerly the refiners of the American seaboard used chiefly Arizona raw material, but as the smaller mines collapsed, and some of the largest concerns were controlled by one of the works, the others were forced to seek new sources of supply, and naturally turned to the treatment of Montana mattes. Then the second largest mine of that section built its own refining works. Taking these two facts together the offerings of ingot copper in our market increased, although the production was falling off. As the import returns in England show that market was relieved, while our own was put under increasing pressure. Arizona and Montana copper was steadily and successfully making inroads into territory long held and still claimed by the lake companies. In the brass trade it is estimated by different authorities that the cheaper grades of casting copper may be substituted for about one-half to two-thirds of the weight consumed. The lake copper companies had to face the problem of an actual over-production of high-grade copper, and to decide whether or not it would be policy to force sales in this country in competition on nearly a level of equality with other brands, or whether it would be wiser to give up the sale of their product for all but the purposes for which its high quality makes it a necessity, and sacrifice the surplus abroad. The events of the past years have taught that not alone the excellent copper made from Arizona ores, but also the metal extracted from Montana material, is good enough for a very large percentage of the total consumption. The temptation of a difference in price, ranging from ½c to 1½c, was too much for the majority of manufacturers, and the lake metal has been losing ground. Last year, out of a total production of 72,000,000 lbs., about 28,000,000 lbs. of lake copper, or a little less than 40 per cent., were exported, and in the case of some individual companies it reached nearly 50 per cent. Thus far this year, unless the movement were arrested, a still heavier proportion would have to go abroad. The Calumet and Hecla company have chosen to have a fight for the trade of those who can get along with other brands, and this, I take it, is the principal motive for their action. This action of the Calumet and Hecla will undoubtedly be a severe blow to a number of incipient enterprises launching to revive older Lake Superior mines. It crowds closely the few Arizona concerns now running, and may induce some of them, which are not forced to run until exhausted financially, to restrict production or stop entirely. It will, furthermore, wipe out the small margin in making copper in the Butte district, and will divert more of that material to England and the continent, or compel the companies there to make a determined effort to lower cost by reducing wages. It will, furthermore, induce some sellers to withhold their supplies, at least for a time, and will compel outside brands to seek a new level of values, probably not so remote from that of lake ingot as hitherto.—*The Ironmonger* (London).

GUTTA-PERCHA.

The demand for gutta-percha has been increasing of late years at so rapid a rate that there is serious reason to fear that for some time past we must have been consuming the gum at a greater proportional rate than the trees which are annually cut down can be replaced.

The gutta-percha tree (*Isonandra gutta*) is found chiefly in Further India and the Malay Archipelago; while the india-rubber tree (*ficus elastica*) is also found in Further India and in Assam, although the principal supply comes from the South American forests. It has for some time been known that other trees are to be found in the forests of southern Asia which yield juices having properties similar, if not identical, with those either of gutta-percha or of india-rubber. But, unfortunately, these trees are either excessively rare species, or, if they ever are found in any quantity, it is only in the most inaccessible places.

Now, however, it appears that the continent of Africa is likely eventually to supply our requirements. The karite tree (*Bassia Parkii*) is very abundant throughout the whole continent. Hitherto, it has only been known as yielding from its seeds an oily matter, which is largely used by the natives for various purposes. About twelve months ago, a note was presented to the French Academy of Science, by M. Heckel, in which he announced that the coagulated gum of the karite tree possessed properties very

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similar to those of gutta-percha. Still more lately, M. Heckel and F. Schlagdenhaufen have made a more thorough and minute examination of both the physical properties and the chemical composition of this material, with the result that it appears that the two products are approximately identical. The karite can be kneaded in warm water with the same facility as gutta percha, and moulds made from it are equal to the best quality of percha moulds.

It would, therefore, appear that this substance is likely to become a most important commercial product in the near future. And as it is said that the whole length of the valley of the Nile is particularly well adapted for growing the tree, the matter would seem to merit the attention of the English government.—*Industries.*

WEAR AND TEAR.

In estimating the depreciation due to wear and tear in engines, shafting, belting and machine tools, due regard should be had to the general system upon which they are run, whether they are allowed to wear themselves almost entirely out and are then replaced by new ones of which an inventory is taken, or whether they are kept up to a certain standard of goodness by the replacing of worn parts, etc. The latter is the system practised by the writer for many years past, and is, in his opinion, undoubtedly the best one. Leaving out the question of obsoleteness, there is no reason why a lathe or planer should not be run for twenty or thirty years and kept up to the standard (by frequent repairs and replacement of parts) to which it has attained in the third or fourth year of its age. Shafting and pulleys can be regarded in the same way, but can probably be kept nearer to a new standard, as they do not wear out so fast. Belting also can be treated upon the same principle, but kept at a lower standard, the average condition of a lot of belting throughout a shop usually being probably nearly half worn out. The writer intends, for his own use, to establish for these classes of machinery, and also for small tools, such as twist drills, reamers, etc., a standard percentage of "worn-outness," if such a word may be coined for the occasion. He has not yet made an accurate estimate of the proper percentage to be employed in each case, but probably a fair allowance for the percentage of present new value in a well-equipped and properly taken care of machine shop (leaving out, as before intimated, the question of obsoleteness) would be, for shafting, etc., eighty to ninety per cent., engines and machine tools seventy to eighty per cent., boilers and belting sixty to seventy per cent., and small tools (which are constantly being ground away) fifty to sixty per cent. This estimate is, of course, only approximate, and its correctness would vary with the standard of condition which was adopted, and the consequent thoroughness and frequency of repairs. —*Engineer.*

MACHINES AS A GROWTH.

Machines are not as a rule the product of the genius of one man alone, but of the successive labors of many minds, and are a growth rather than a sudden creation. No doubt many simple machines are made and perfected by one inventor, but the completed machine is arrived at even then by a gradual process. In the great majority of cases, however, in which this is apparently the case, the inventor really started from the vantage ground of the results of the previous worker. This was eminently the case in the development of the steam engine. But to take another example: The dynamo, which as a machine is very simple, is quite a modern invention, but before Siemens, Gramme and others evolved the well-known machines bearing their respective names, Pixii had in 1833 constructed a magneto-electric machine in which the magnet revolved and the coil was fixed. Saxton had improved on this with a machine in which the magnet was fixed and the coil revolved, and Park had again improved on the machine of Saxton. The study of the history of machines shows us incidentally how the typical inventor has worked. He has some object in view which he strives to accomplish. In some rare instances, as in the case of James Watt, he studies the scientific principles, but even then the process of invention is more or less a groping in the dark on some of the steps in which the light of scientific knowledge is flashed, while in most cases it is in almost total darkness. Thus, as Reuleaux has pointed out, there arises that reverence for the inventor which is greatly due to the fact that he has succeeded by a process which is unintelligible even to himself. The result of this absence of scientific method is shown by the fact that the lot of the large majority of inventors is simply failure. The statistics of the patent office furnish striking testimony to this assertion.—*Manufacturers' Gazette.*

PROPER SIZE OF STEAM ENGINES.

There is an idea widely prevalent among steam users that the best results from the point of economy in coal and power, may be obtained by the use of an engine that is much too large for the actual needs of the work required. The fallacy of this position has been demonstrated by carefully conducted experiments. If a 10 h. p. engine is required to do the work, no man would think of purchasing either a little 3″ x 2″ machine, or one with a cylinder fit for a steamship. Both of these bear upon their face their unfitness for the work proposed, and their wastefulness would in each case be greater than that of an engine more nearly the size required, and the running expense would approach nearer and nearer the minimum, until exactly the right size was struck. And it will be found that for any load there is one size and only one size of engine that will give the greatest economy. This is due to the fact that for every engine there is a certain amount of friction that may be considered constant, and which increases with the size of the engine. For engines too large for the work required, this initial friction will consume too large a percentage of the total work performed, destroying the economical working, while for engines too small, the increase of resistance and the impossibility of using the steam expansively kills economy on its side.—*Power.*

BEHIND THE TIMES.

However excellent in discipline and equipment its department may be, the city or town that has no fire alarm telegraph is deficient in one of the most important essentials to the adequate protection of life and property; yet we could give a long list of pretentious places in which the old custom of desultory bell-clanging still prevails, and we regret to add that in many of them it seems likely long to remain in vogue.

It is an axiom that the more promptly a fire is attacked the more favorable are the chances for its extinction with the least possible loss, and as no alarm system yet devised can compare with the telegraph for quickly summoning the firemen to a particular point, we cannot understand the hesitation to adopt it in places whereof we speak. When its usefulness is fully considered, the expense of its introduction and maintenance sinks into insignificance; and where once it has been tested the people soon come to wonder how they could have been so long insensible to its advantages.

The present is popularly supposed to be a progressive age; but it is apparent that there are many nooks and corners in which the spirit of progress may yet manifest itself with telling effect.—*The Firemen's Standard.*

A NEW ELECTROTYPING SOLUTION.

Dr. Gore, F.R.S., the well-known authority on electrodeposition, has discovered that an aqueous solution of

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asparagine is a good medium for electrolytic baths. The solution he used was not quite saturated, and consisted of about .88 gramme of crystals of asparagine dissolved in 18 cubic centimetres of distilled water. It was feebly acid to the test paper, and was employed at a temperature of about 70° Cent. Some of the liquid was more or less saturated with different metallic oxides, and the resulting baths electrolyzed by currents from one to six cells of zinc and platinum in dilute sulphuric acid. Good deposits of cadmium were thus obtained, .23 gramme of hydrate oxide of cadmium dissolved in 20 cubic centimetres of the solution, using an anode of cadmium and a cathode of copper. Zinc was deposited from .28 gramme of zinc oxide in 23 cubic centimetres of solution. Magnesium in a film was also deposited from calcined magnesia with magnesium and copper electrodes; copper was obtained from cupric oxide with copper and platinum electrodes; mercury from red mercurous oxide with platinum electrodes; and silver from oxide of silver with a silver anode and platinum cathode. In the latter case the deposit was good, the bath consisting of .33 gramme of silver oxide in 20 cubic centimetres of asparagine solution.

A PROBLEM IN NATURAL PHILOSOPHY.

The question is often asked why the filament of an incandescent lamp looks, when white-hot, so much larger than when cold. It might be said that the filament or thread or wire of carbon expands when heated, and consequently looks larger because it is really of greater size. Now, the expansion of carbon is very slight, and would not account at all for the apparent increase in size. If, however, we examine the white-hot filament through a piece of glass covered with smoke or steamy vapor, it appears no larger than when cold. When some of the nerve-ends of the retina of the eye are excited by light, the excitement extends to some degree to the neighboring nerves. Thus, a narrow white-hot wire affects, especially from a distance, more nerve-fibres of the retina than really receive the rays of light, and the sensation received is that of a large wire. This phenomenon is called irradiation. The moon, when partly full, appears larger than the part which is dark. A certain degree of accuracy, in judging of the candle-power of a lamp, can be attained by practice in noticing the varying apparent size of the filament when at different heats, and consequently at different candle-powers.

A LONG-FELT WANT SUPPLIED.

The Universal Tinker Company has recently been formed in Chicago, with $5,000 capital. The plan is to solicit a number of subscribers and, for a payment of $3.00 per month, the company will make all necessary repairs about the house, except general contracting. It would attend to putting in window panes, mending gas leaks, keeping the waste and other water pipes tight, shutting off escaping sewer-gas, looking after the electric bells and reinforcing the batteries, repairing doors and windows and loosening up the tight ones, winding the clocks and keeping them regulated, mending roof leaks, repairing toys, packing the water pipes to prevent freezing, and, in fact, looking after a thousand and one other things in dwelling and business houses. The new company will start with ten first-class mechanics, and each subscriber will be visited once every week. There will also be telephonic communication, so that cases of emergency can be looked after at once. The incorporators claim that each subscriber will not only rid himself of a vast amount of trouble, but that he will save money.—*The American Engineer.*

A NEW SECONDARY BATTERY.

Herr Kalischer has devised a secondary element of iron and lead in a concentrated solution of lead nitrate. The iron anode is passive, and with currents not too strong becomes coated with coherent thick layers of black peroxide of lead, which protect the iron from contact with the liquid and from decomposition. The change is completed when gas is freely liberated at the anode, and the liquid gives only a slight precipitate with sulphuric acid. To prevent lead growths between anode and cathode amalgamated lead in contact with mercury is used. In discharging, the peroxide becomes brown, and changes into monoxide, then into black peroxide. The electromotive force is from 2 to 2.5 volts, but sinks, when the current stops, to 1.8 volts. From its solubility in nitric acid the lead cathode must be occasionally replaced. Carbon can be used instead of iron.

THE ELECTRIC RESISTANCE OF WOOD.

Mr. Addenbrooke, of the United Telephone Company [England], has made a series of tests of the resistance of timber, the measurements being made by inserting terminals 2 inches apart in well-seasoned, sound pieces of the woods 3 inches by ¼ in. by ⅜ in. in size. The pieces were kept for some time in a dry warm place to prevent surface conduction by moisture. The comparative resistances were, for mahogany, 48 megohms; for pine, 214 megohms; for rosewood, 291; lignum vitæ, 397; walnut, 478; and teak, 734 megohms, respectively. These results were obtained with the electric current flowing in the direction of the grain; other measurements showing that when it flowed across the grain the resistance was from 50 to 100 per cent. greater.—*Engineering.*

IMITATING LEATHER SURFACES.

By means of electricity the most attractive leather surfaces are now completely imitated. The leather which it is desired to imitate is first well cleaned and coated with graphite, as in electro-plating a smaller article. It is then placed in a copper bath, the tank of which is large enough to easily receive a skin of any size. A dynamo-electric machine generating a powerful current furnishes the current. The copper is deposited upon the coated surface of the hide to a thickness of one-sixteenth to one-eighth of an inch. The plate thus formed reproduces, but reversed, every mark and minute vein of the leather, so that a print taken from it is an exact copy of the original in every detail.—*Boston Journal of Commerce.*

EFFECT OF ELECTRICITY ON THE GROWTH OF ROOTS.

An interesting experiment, showing the influence of electricity on the growth of roots, has been made in Germany. Plates of copper were thrust upright into the earth, and connected by wires with similarly placed zinc plates about 100 feet distant, an electric battery being thus formed with the earth between the copper and zinc in the circuit. Both potatoes and beets planted between such plates give an increased yield: beets 15 per cent., potatoes 25 per cent., as compared with other parts of the same field.—*English Mechanic.*

MAGNETIC FORCE LINES.

A bowl is filled with water and lycopodium strewn on its surface, the superfluous powder being afterwards blown away. The bowl is then placed in the spot whose magnetic field it is wished to investigate, for example, at the pole of a magnet. Very fine iron powder is then allowed to fall into the bowl from some height. On slightly shaking, the forms of the force lines form on the surface of the water by means of the iron powder borne by the lycopodium.—*The Electrician* (London).

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ALTERNATING CURRENTS AND THEIR PRACTICAL USES.[1]

At first only battery, and consequently continuous and constant currents were known. Their E. M. FS. are small, and for a single arc light they needed an army of cells which filled a whole room.

Later, after the discovery of induction, when they recognized the physiological action of the current, they made use of induction to generate higher E. M. FS. They transformed battery currents, which possessed so low an E. M. F. that they could not touch the nerves at all with them, into currents of high E. M. F., which were capable of strongly affecting the nervous system. These currents were either extra currents or secondary currents, produced with a sliding apparatus or Rhumkorff coil. These currents of higher E. M. F. were induction currents, and, what induction always generates, alternating currents.

Hence arose the misconception, somewhat prevalent in Germany, that alternating currents were dangerous.

If we close a battery of a few elements by a circuit in which there is little induction, such as, for instance, a series of glow lamps, we can break this circuit a hundred times quickly or slowly, without any action being felt. But if the same battery is closed by a conductor of considerable self-induction—for example, by a coil of many windings with an iron core in it, then every interruption will be felt plainly enough. The interruption of one and the same current is in one case physiologically actionless, in the other of strong effect. The interruption itself exercises no action, but the strong E. M. F. and current generated by the induction does.

To illustrate the matter further, let us consider a dynamo machine, with powerful magnetic fields—for example, an Edison machine. The arms of the magnets are wound with immense long coils of copper wire, and these coils are united with the binding screws of the machine to form a shunt circuit. The potential difference at the binding screws amounts to about 100 volts. The magnet coils consequently experience an E. M. F. of only 100 volts. Nobody need be afraid of laying hold of the ends of the wires of these coils with their naked hands, for we know that an E. M. F. of 100 volts is harmless. On the contrary, let any one beware of touching these wire ends at the instant when the circuit of the magnet coil is suddenly broken. By the sudden demagnetization of the iron there arises in the long coil an instantaneous current, whose E. M. F. may reach many hundred volts. But if we break the outer circuit which is formed of glow lamps the interruption is scarcely perceptible.

Other chance circumstances have assisted to confirm this erroneous opinion. The period, about eight years ago, is remembered, when the division of the electric light, as it was called, was found out, viz., that they could keep up several arc lights in series by one dynamo machine. First came the Jablochkoff lamps, for which Lontin and Gramme invented their alternating machine, and then the division lamps of Siemens, which were fed by Siemens alternating machines. Thus there came for the first time currents with great E. M. FS. into practical electric lighting, since it is evident that a series of lamps must have a higher E. M. F. than a single one. We now heard for the first time, "Take care, you are warned not to touch the conductors," and, because these currents of high E. M. F. were also alternating currents, they again thought that the danger lay in the currents being alternating. That the continuous currents of Brush, which were soon after introduced with their 1,000 and 2,000 volts, brought more danger than all the alternate currents was not noticed.

It is not the quality of the current, not its duration, direction, etc., which is the test of its danger, but solely the *difference of potential or E. M. F. to which the body is exposed, that is the difference of potential between the two points where the body is in contact with the circuit.* Consequently, an electric current, be it uniform, intermitting, or alternating, may be dangerous if it possesses a high E. M. F., and every electric current is perfectly harmless if it possesses a small E. M. F.—for example, 100 or fewer volts.

From the point of view of safety it is a necessity with all electric currents, whatever their name or origin, that in house conductors and lamps, which are tended by unskilled persons, only such currents should be used as have not a high E. M. F., and that such conductors as carry currents of high E. M. F. should be made inaccessible to unprofessionals.

Again, many think that alternate currents are not so effective as continuous currents. This opinion is also in most cases erroneous.

Let us consider a single coil of wire which we move in a magnetic field. Its plane cuts the lines of force. As long as the number of force lines inside the coil remains unaltered there is no resistance to the motion, and no current is generated in the coil; only when the motion alters the number of lines of force does the magnetic field offer a resistance to the motion and awake an electric current either in one direction or the other. If the coil move from a weaker to a stronger field, an electric current circulates in one direction; on the other hand, if the motion is from a stronger to a weaker, the current is in the opposite direction.

If we had an infinitely extended magnetic field in which the intensity varied continuously, we could by a continuous motion of the circuit call forth a continuous current. But since this is impracticable in reality, and we have only a limited field in which the coil must move, it is impossible but that we should have currents which alternate more or less rapidly equally whether the motion is rotatory or oscillatory. Consequently, we have always alternate currents in the armature of a dynamo machine, never continuous ones like those of batteries and thermopiles. It is only outside the machine that the current of a dynamo can be made continuous. The commutators serve for this purpose, or the ingenious collectors introduced by Gramme.

There is, indeed, a practical difference between continuous and alternating machines, and in this difference the alternating machines have an advantage. This difference does not exist inside the machine, but in the manner of collecting the currents. The continuous machine must have a commutator or collector, by which its whole current is taken, and that is its weak part. The currents of the alternating machines, on the other hand, are caught in their natural state, and as they have arisen they go out into the circuit, either from contact rings which have uninterrupted and constant contact, or still better by fixed binding screws direct from the armature.

Even with alternating machines the tiresome process of commutation, alas, is not quite avoided, for these machines also need continuous currents for the excitation of their magnets. But the evil here is much smaller than with continuous current machines, other things being equal. With a 100 h. p. continuous machine, for example, we have to reverse 600 to 700 ampères; with a machine which differs only in being alternating only 20 or 30 ampères, the E. M. F. being the same in the two cases.

On this account one is less trammeled in the construction of large alternating machines than in the case of continuous machines. An Edison 1,000-light machine is looked upon as a colossus. On the other hand, an alternating machine for 4,000 to 8,000 lights is no particular masterpiece.

The reason of this lies in the fact that the induced coils need not be brought together to a collector by an innumerable number of connecting wires in an alternating machine as in a continuous machine. The armature wires can rather be so conveniently distributed on the outer periphery of the whole construction as is most suitable for the efficiency. These wire coils may, if we please, be made stationary, whilst the more massive parts of the machine

1. Abstract from a paper by Max Deri in the *Zeitschrift für Elektrotechnik*.

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are made to rotate. Such arrangements have hitherto been sought to be made in vain with continuous machines.

Hence arises the fact that alternating machines do not require such rapid rotation as continuous machines. Continuous machines which make less than 500 turns per minute are not frequent. Alternating machines require for the same performance about half the number of revolutions. There are plenty of alternating machines which work with only 150, and even fewer revolutions. That this property from a technical point of view is very valuable, nobody can doubt.

The alternating machines have another advantage over the continuous machines, which, in my opinion, cannot be enough insisted upon. It is well known how difficult it is to generate with a dynamo machine currents of high E. M. F., for example, of many 1,000 volts. In the armature of a continuous machine, which must form the most compactly constructed part of the apparatus, it is unavoidable pushing very close to one another such points of the current-yielding wires as have very considerable differences of potential. The wire coils themselves are mounted very closely together; their connecting wires and the sectors of the collector are pushed still closer together. The danger of a current of great E. M. F. leaking through from weakness of the insulation is consequently very great.

The relations of rightly constructed alternating machines are much more favorable on these points.

There is no argument to show that alternating machines should not work with just as good, useful effect, and should not be as satisfactory in their performances as continuous machines, and, indeed, I have shown you properties of alternating machines which may enable them to surpass other dynamo machines.

What has just been said refers rather to the alternating machines than to the currents which they generate. Before speaking of the currents we will return to induction. It was shown how electric currents are induced by the motion of a conductor in a magnetic field, and that such currents are in practice always alternating currents. It may be added that this induction, as is well known, is very much strengthened by the use of iron.

The author goes on to speak of the rapid reversal of the magnetic force lines of the iron by an alternating current, and of how this rapid reversal may generate currents in any conductor in their field. He speaks of the great advantage of transformators in the conversion of electric energy.

He says the negative E. M. F. of a coil traversed by a current and consequently also the E. M. F. of a secondary coil depends evidently on the course of alternation of the current and on the properties and dimensions of the matter in which the force lines develop themselves. In induction of force lines iron far surpasses all other bodies. Its permeability for magnetic force lines it has been shown is many hundred times greater than that of air. Consequently, the more iron is employed and the more fully the space in which the force lines describe their path is filled with it the stronger is the action. When the force lines issue into the air, poles are formed and the force lines are dispersed. For the strongest action closed iron circuits should be used which have no poles.

To avoid losses in the induction care must be taken to avoid any metal work (except the secondary coil) coming into the range of the force lines, else the parasitical currents known as "Foucault's currents" will be induced in.

Good conductors should be used for each kind of induction—iron for the magnetic and copper for the electromagnetic. It is simplest to employ wires of small cross section for both. The iron wires are arranged parallel to the force lines engendered by the current, that is perpendicular to the current, and the copper wire of the secondary circuit parallel to that of the primary one. All the wires should be insulated. In such an arrangement no parasitical currents can arise, for the insulation of the iron wires prevents their formation in the core.

He then quotes as an example of a transformator one in which for a consumption of 7,560 watts by the primary coil, the secondary gives 7,200 useful watts, that is, it has an efficiency of 95.2 per cent.

He says that a dynamo machine must always have two defects in comparison with a transformator:—(1) The loss by friction in the motion; (2) the dispersion of the force lines in the air.

The action of alternating currents is to be very much valued, in that it renders transformation possible. It is a benefit to be able to work with high E. M. FS., which are indispensable to overcome distance, and then to be able to get rid of them, and transform them into comparatively low ones when we no longer require them or they are inconvenient.

The alternating current can be employed just as well as the continuous current for the production of light and warmth. In the production of light there is to be sure, some difference in the working, but only with the arc light. The continuous current has here the advantage that it hollows out a crater in the positive carbon, which acts as a natural reflector, and so produces downwards a more favorable lighting effect. On the other hand, an alternating current has the advantage that both the carbons wear out in the same manner.

For glow lamps the lighting action of both kinds of currents is perfectly equal.

For motors up to the present time the continuous current has been almost exclusively employed. But thereby it is by no means implied that alternating currents cannot also produce motive work. I even assert and do not rest upon my own individual views alone, but upon the results of experiments which are not yet terminated, that alternating currents will also be found useful in the working of electro-motors, and will enter into competition with continuous currents.

Continuous currents must, however, be given their due in one particular. Alternating currents are useless for electrolysis, and consequently they are unfit for all metallurgical work. They cannot either be employed with accumulators. This province belongs entirely to continuous currents.

This is, however, the only province wherein alternate currents yield to continuous currents; everywhere else they will dispute the field with them.

THE EFFECT OF LIGHTNING ON HUMAN BEINGS.

The effect which a stroke of lightning exercises on human beings has, no doubt, been often seen and described, but there is nevertheless much about it that is obscure. At the last meeting of German scientists at Hamburg, Dr. Heufner described certain cases which had come under his immediate notice, whereby some exceedingly remarkable physical effects of being struck by lightning were demonstrated. The principal contents of his report were as follows:—

Sunday, July 13th, 1885, a horse race was to take place at Barmen, to which a number of spectators flocked in spite of an approaching thunderstorm. The course was enclosed with canvas stretched between poles in the ground, and, as this wall afforded shelter against the wind and rain, which soon began to play, the spectators crowded against it. Suddenly a stroke of lightning descended, split two poles, tore away a large portion of the canvas, and felled twenty persons to the ground. Four of these were killed on the spot, and sixteen recovered consciousness in the space of a few minutes to an hour. The greater number of the sufferers were treated by Dr. Heufner, and from the others he received detailed statements. According to those who had at once rushed to the assistance of the persons

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struck, their faces bore an ashen color, their countenances were distorted, and the extremities cold as ice.

One lady, severely struck, felt, on regaining consciousness, an intense giddiness, "as if a wheel spun round in her head." She remained almost insensible till the following day, complaining greatly of weakness and pains in the limbs. Her legs were for several hours pale and cold and insensible to touch, but in the sole of the foot she felt stinging pains. Behind the left ear, as far as the shoulder, ran a broad irregular burn or scorch, in the centre of which the skin had become hard as leather. Smaller burns and red spots were found on the right breast and the right arm. By the sole of the foot on both sides there were circular greyish-white spots with perforated centres, surrounded by lacerated and fatty scorched masses of the epidermis. These spots were situated at the edge of the toes, and showed little reaction during the first few days, whereas the burns on the upper parts of the body began to swell on the following day. In shape they reminded one of the hole which an electric spark makes in a piece of cardboard. By the sole of the foot of one man there were no less than twenty-four apertures of various kinds, and a corresponding number was found on the boot of the sufferer. All the holes were also in this case situated in the lower edge of the upper boot, only very fine ones being found in the actual sole. Hardly bigger were the holes Dr. Heufner found in the boots of another of the sufferers he examined, and he says, "it seems remarkable that lightning possessing the power of striking a man dead on the spot, should be able to find an outlet through such tiny openings." With persons who wore shoes studded with metal knobs there were no holes in the soles, as the former had doubtless acted as conductors. The damage made to the clothes of the sufferers was, on the whole, very small, but in the spots where the body bore burns, the coat and waistcoat showed small round holes half a centimetre in diameter. In the lining and the underclothing the holes increased in size, those in the shirt being as big as a shilling. In the hat of a boy there were three holes through the felt, about the size of a quill, whilst those in the lining were much larger. The hat with its many perforations demonstrated that the lightning had not descended in a single stroke, but in several.

The great increase in the destruction of the lining and inner garments is doubtless due to the circumstance that the electric current encounters a considerable degree of resistance through the non-conducting qualities of the epidermis, which causes it to develop its greatest energy in this locality. It is also the resistance of the epidermis which causes the sudden and violent rupture of the skin, resulting in great injury to the same. Except those who were lightly struck having only solitary burns or red spots, all the others had on the upper part of the body several burns of various sizes and irregular shape, whence red streaks radiated more or less over the body and limbs, and which after a while became covered with a crust. In some cases the hair on the skin was singed in a streaky manner, clearly proving that the lightning had passed across the skin ; in others the streaks formed tooth-shaped and bifurcated figures, such as are drawn in text-books of physics for illustrating the so-called lightning figures.

Quite different was the injury done to the feet, and, may be, this difference between the wounds of the upper and lower parts of the body is due to a polar variation of the electric current. It is, we know, a fact, that the positive pole affects the human body differently to the negative.

When the current reaches the moist part in the interior of the body it may without difficulty and without doing much damage strike in all directions; this applies chiefly to the brain, the spine, and the eye, which are some of the best conductive parts of the body. It is for this reason that a stroke of lightning hitting the head is not always mortal, and that the exterior apparent injury shows a strong contrast to the intact state of the skull and brain. This was, for instance, the case with a boy fourteen years of age, who, in the middle of the forehead, just under the hair, had a burn about the size of a shilling. Four days after the catastrophe the boy—whose skin on the forehead and upper eyebrows was very red and swollen, and whose eye-lashes were singed—presented a frightful spectacle. He showed every sign of a great shock to the brain, the closing scenes of the race having entirely disappeared from his recollection, whilst he also during the same period suffered greatly from vomiting, and was for several weeks in a very low state, *but he suffered no permanent injury to the brain whatever from the stroke.*

Besides the injury to the head, this boy had for several months a burn on the upper rib, whence an incrusted scar ran behind, and, parting into two streaks above the loins, continued down the back of both legs to the heel. His terribly injured feet were at first very cold, remaining benumbed for hours at a time, then they became very swollen, phenomena which were also observed in the other sufferers, and which may perhaps be connected with cramp experienced at first and the subsequent paralysis of the muscular system.

It is generally stated as an important fact that persons struck by lightning have no recollection of the occurrence. Lightning, with its enormous velocity, paralyzes and kills before its light can reach the ocular, or its sound the oral, nerves, and the victim thus become conscious.

The lady referred to above would not believe, when told so in the hospital, that she had been struck by lightning ; and a man who on recovering, hearing her cries for help, attempted to rush to her assistance, found to his great surprise that he could not move a muscle. This again seems to explain the strange circumstance that those who have been struck by lightning, as a rule, show no fear or excitement, but rather apathy.

Several of those struck in this case had, however, some recollection of being hit, having, doubtless, first suffered unconsciousness a moment later. One of them related that he had felt being struck and sinking down with a sensation as of being torn to pieces. Another stated that he felt a blow in the neck as from a thick stick, and he became always afterwards very frightened during a thunderstorm. A third, who still recollected seeing a man falling ashy pale by his side, compared the shock he felt when struck, to the blow of a sledge hammer on an anvil without its rebound.—*Electrical Review* (London).

THE REGENT PRIMARY BATTERY.

THE Regent primary battery is the invention of Mr. S. W. Maquay, of 17 Craven street, Strand, where it is now on exhibition every afternoon. The feature which distinguishes the battery is the small amount of local action on the zinc plate. This is a characteristic which is of more importance than appears at first sight, for not only does local action destroy the zinc, whether the battery is at work or at rest, but it also uses up the depolarizing fluid, which, as a rule, costs more than the metal. Thus, there is a double loss, which continues all the twenty-four hours of the day, although the battery may only be in useful operation for a short time in the evening. It is customary, of course, to stop the local action by the device of amalgamating the plates, but the operation needs to be often performed and is exceedingly dirty and disagreeable. Even in laboratories it is always deferred until the waste is going on at an excessive rate, and in electric lighting for domestic purposes it becomes an impossibility. No servant would undertake the task of amalgamating a set of zincs more than once, and as long as this process remains essential the use of primary batteries in households is out of the question. Now Mr. Maquay avoids the operation by amalgamating his zincs throughout the mass, that is, by casting them from an amalgam of zinc and mercury. This has been tried before, that is, mercury has been added to the

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metal in the ladle, but without much success, as most of the former metal was evaporated before the castings had set. Mr. Maquay, however, forms a preliminary amalgam with another metal, such as lead or tin, and then he adds this amalgam to the zinc, the result being that he gets a perfectly homogeneous mixture or alloy in which the three metals are uniformly diffused throughout the mass. Consequently every particle of zinc is amalgamated, and as the plate gradually dissolves there is always a clean surface presented to the acid.

The reduction of local action involves a reduction in the amount of hydrogen evolved, and consequently in the tendency to polarization, which has been the bane of electric lighting batteries hitherto. They have all of them given a good light when freshly charged, but in a few hours, often not more than two, excessive polarization has been set up, the electromotive force has been reduced, and the light has rapidly fallen. In the Regent battery, however, the electromotive force remains practically constant for many hours. In an experiment made by Professor J. A. Fleming on a cell measuring 5 in. by 3¼ in. by 1¾ in., the current strength only fell 4½ per cent. in five hours. The internal resistance of the cell was .260 ohm., and the external resistance .845 ohm., the current strength being 1.75 ampères. The consumption of the zinc plate was 12 grammes, or at the rate of 2.2 lb. per 1000 watt hours. When the cell was allowed to stand inactive it was found that the zinc plate wasted at the rate of ¼ per cent per hour. As a matter of ordinary practice, a battery can be run about ten hours, after which the solutions require to be renewed. Several ways have been already devised for employing and filling cells by simply turning one tap to discharge the spent fluid, and by opening a second to replace it with a fresh quantity, and it would be an easy matter to scheme a dozen more. This is a point which has been much neglected by inventors. They do not realize the great simplicity which is required for success, and when they have perfected their electrical features, they appear to think that all is done. The obstacle to the use of batteries is not so much the cost, while they are working, as the waste which goes on at other times, and the trouble of attending to them.

One form of the Regent battery has a special interest at the present time. It is constructed to form a miner's lamp. Its weight is 2 lb. 11 oz., or just the same as the existing Davy lamp, and its light more than a candle, which is greatly in excess of the illumination which is afforded by the safety lamps in use.—*Engineering.*

GAS vs. ELECTRICITY.

Mr. H. G. Massingham has written the following interesting letter to the *Taunton Courier*:—"Dear Sir: In a leading article on the annual meeting of the Taunton Gas Company you say, 'Both the general public and the shareholders in the Taunton Gas Company must feel some considerable amount of pleasure in the roseate state of affairs which Dr. Kelly was enabled to present at the recent annual meeting.' As one of the 'general public' it certainly did afford me considerable pleasure to read your congratulatory article. It is now nearly twelve months since I first suggested the desirability of introducing the electric light into Taunton, owing to the numerous complaints of the insufficient lighting of the town, and I at once met the very natural fears of the gas shareholders by stating it would create a demand for more light, and tend to increase rather than decrease the consumption of gas. In addition to which, gas would in the future be more used for cooking, heating, etc., for which it is better adapted than for lighting purposes. I am pleased, therefore, to see that my prediction has been more than realized. I can add my testimony to the great convenience of gas cooking stoves, and also the undoubted economy of using these during the summer months, when fires are not required. I feel the more pleasure in doing this owing to the fact that some of the gentlemen connected with the local gas company cannot forgive me for introducing the electric light into Taunton, but I hope that before long they will realize that while I have tried to benefit the town I have in no way injured their particular interests. Unlike the gas shareholders, I cannot congratulate myself upon any return for my capital, but I have the satisfaction of knowing that I am doing a useful work, and I am pleased to say that were I not giving away the light from the seven parade lamps (which will cease in December) I should be covering all expenses, which is highly satisfactory to me, as I purposely decided to supply the light at the cost of production, directly the local syndicate declined the risk, and I undertook the sole responsibility. Had a local company been formed, as they would have been receiving 10 per cent. more than I am charging, they would have paid a dividend of from 6 to 8 per cent. by the end of the first year."—*The Electrician* (London).

GAS AND ELECTRICITY IN PARIS.

It is reckoned that there are now in Paris 16,044 incandescent lamps, and 2,225 arc or Jablochkoff lights. The *Bulletin Internationale de L'Electricité* of this week gives an interesting analysis of the effect of this large number of lights on the Parisian Gas Company. Admitting that each incandescent lamp replaces one jet of gas, and that each arc light is equivalent to ten ordinary burners, an estimate—which our contemporary considers very moderate, and one which gas manufacturers themselves cannot regard as exaggerated—this would represent in round numbers 38,300 gas burners lost to the Paris Gas company. At the rate of 140 litres of gas per hour these burners would consume 5,362 cubic metres, taking them to be lighted on an average for four hours a day during the whole of the 365 days of the year. This would amount to 7,755,520 cubic metres, which at the rate of 0.30 centimes per cubic metre would put into the coffers of the company 2,326,656 francs. This sum is very considerable, but there has to be added to it what would be obtained from the sale of residual productions in the manufacture of this great quantity of gas if the electric light did not exist. In the face of such facts it is not surprising that the progress of the new illuminant is attracting in an unusual degree the attention of persons interested in the Parisian Gas Company.—*The Electrician* (London).

THE BRUCE ELECTRICAL BALLOON.

The Bruce electrical war balloon, for flashing signals by night, has been exhibited at Lillie Bridge Grounds, West Brompton, where some experiments in army signaling were made. The balloon has been previously described; but we may mention for the benefit of those who are not familiar with the balloon that it is made of translucent cambric, and has a capacity of about 4,000 cubic feet. It contains six glow lamps perfectly isolated from the gas which surrounds them, and connected with the battery on the ground by a cable which at the same time holds the balloon captive. When the balloon is at an elevation of 500 feet, the flashes are visible to the naked eye at a distance of sixteen miles, and a message delivered by the Morse code can be read by troops stationed at that distance. The recent experiments were designed to show the feasibility of attaching lamps to the outside of the balloon, whereby they attain a much higher penetrating power. It has been pointed out by some officers of the royal engineers, to whom the invention has been submitted, that it would be useful not only for signaling purposes, but as a preconcerted signal, and as giving a point to march on, or to guide a retreat or advance at night. It has also been shown that it would be of high value as a light for working parties. During the experiments, when the balloon was 15 or 20 feet

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from the ground, it shed over a wide area a light that it was quite possible to read small print by. The experiments were completely successful.—*Engineer and Iron Trades Advertiser* (Glasgow).

THE EDISON FILAMENT CASE.[1]

BY JAMES SWINBURNE.

The enormous importance of the decision in the recent lamp case is gradually coming to be understood by the public. Before, and even just after the trial people seemed to think it was a comparatively small matter, concerning Messrs. Woodhouse and Rawson only; but now they are beginning to see what it may mean to allow the monopoly of incandescent lighting to fall into the hands of one company.

Presumably, Messrs. Woodhouse and Rawson are going to appeal; and it looks as if the Anglo-American Brush corporation does not intend the Edison-Swan company to ride rough-shod over them. As more litigation is thus to be expected a full discussion of the Edison case may be advisable.

The first thing that strikes one is the extraordinary weakness of the defendants in the matter of expert evidence. The plaintiffs, having a doubtful case, naturally had resource to the best "scientific witnesses" they could get, as they could not well get people who understood incandescent lamps to hold the opinions they wanted. The defendants had no witnesses who could contradict them. The case was almost a *reductio ad absurdum* of the expert farce. Probably not one of the witnesses had ever made a lamp himself, or had ever had to do with their manufacture. A great deal has been written lately about expert witnesses. The expert is simply a witness with a sufficiently well-known name for his opinion to carry weight with the judge. The best witness is he who works best with his counsel in persuading the judge to take one or other view. Witnessing is a sort of art in itself, and many men are known as "good witnesses" and make quite an income from this source. To be a good witness it is not necessary to know anything about the subject in question, in fact such knowledge may be a disadvantage, for without it he is more likely to be able to take the views required by his side. It is, of course, impossible even for a witness of undoubted integrity to be impartial.

When a large company wishes to attack a small one, the first thing done is to retain not only the counsel that are wanted to appear, but, it is said, to retain as many of the leading men as possible, at nominal fees, so as to prevent their appearing on the other side. Witnesses are treated the same way. The less powerful litigants must thus appear with less eminent counsel, and, perhaps, are not allowed to secure any counsel at all who have had much experience in patent cases. They are also deprived of the assistance of all the big witnesses.

The only evidence admissible in an incandescent lamp case should have been that of experts in incandescent lamps. No one would dream of denying the position of the witnesses in the scientific world, or of not admitting their authority on any subjects they have specially studied, but the collective opinions of the whole of them on incandescent lamps can carry no more weight than Irving's or Ruskin's writings on America or economics.

On reading Edison's specification, No. 4,576, 1879, we find first that his object is to make lamps that can be used in parallel. He does not claim to have invented incandescent lamps, or to have made them possible; he merely aims at making them of high enough resistance to work in parallel. It was well known at that date that such lamps should have high resistance, and it was well known that carbon could be used for incandescent lamps, and that a long and thin piece of a conductor had a high resistance compared with a short thick piece. It was also known that an incandescent lamp should have as good a vacuum as possible, and should preferably be made of glass with leading-in wires of platinum. The great difficulty was to secure a good enough vacuum to make the carbon durable. A short thick carbon was more durable with a bad vacuum, and so until a better vacuum could be obtained very thin carbons were useless. To make a commercial parallel lamp Edison had, therefore, to make a long thin conductor of a durable substance, and a vacuum good enough for it to last in. The materials known were refractory metals and carbon pure or mixed with earthy matters; and it was known that long thin pieces of either material could be made. Edison rejected the metal and chose carbon either pure or mixed with earthy matters. Edison also had to find a good way of fixing the carbon to the platinum. He says that, heretofore, lamps have had rods of from one to four ohms resistance in inert gases in vessels with metallic bases; He was, of course, wrong; vessels wholly of glass were already well known for lamps of high resistance and low resistance, though the former had metal conductors.

The connection between the carbon and leading-in wires by means of more bulky carbon was also known. He goes on to say low resistance lamps cannot be made with platinum leading-in wires and a glass vessel. He is again wrong; a platinum wire carrying 12 ampères can be sealed into glass without enamel. Edison gives no instructions as to how to make his carbons. He lapses into anecdote and says he has "discovered" that a carbonized thread is absolutely stable at very high temperatures. This is, of course, nonsense. A plain carbonized thread would not do for a carbon; though it would make a comparatively good lamp if treated according to methods then well known, but not mentioned by Edison, and put in a good vacuum. The discoverer goes on to tell how any fibrous vegetable substance will do. Here resort must be made to experiment, for there are very few fibrous materials that will make a lamp that would be good even with the most approved modern methods of treatment. Edison goes on to describe a mixture of lamp-black and tar with camphor or oxide of zinc. It is not clear, therefore, whether this is to be used or not. If a commercial lamp cannot be made with a high resistance conductor of lamp-black, tar, and camphor or oxide of zinc, the patent is void. It is very strange that the defendants did not insist on the insufficiency of the description and the impracticability of Edison's lamp. Edison says all his forms of conductor are so fragile that they cannot be clamped to the leading wires with sufficient force to ensure good contact. This clearly shows that none of his conductors were good enough for practical use. Further down the discoverer resumes the filament of his narrative. He says he has carbonized and used cotton and linen thread, wood splints, paper, and lamp-black, graphite and tar. Now, not one of these materials without further treatment would make a practical lamp even with a good vacuum.

Turning to the claims. The first evidently refers to his particular way of making filaments and of securing them. The expression "filament of carbon of high resistance," would show that a filament need not have high resistance. This, with the rest of the specification, would lead one to suppose that by filament Edison meant something fibrous. He never calls his tar conductors filaments, or his fibrous conductors wires. No doubt, by carbon wire, he meant the tar compound, and by filament the fibrous conductor. The second claim depends, of course, on the meaning of the term filament. If filament means a long thin thing, his claim is for a conductor made thinner than usual, and nothing more. If filament means fibrous material, the defendants do not infringe it. At first sight it seems odd that Edison would describe carbon wire and not cover it, but it is probable that Edison did not think it of any use. This point will be discussed further on. His third claim does not claim

1. *Electrical Review*, London.

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anything now useful, and it is probably bad as being an obvious application of a known method, and might therefore of itself invalidate the patent. Claim 4 calls for no remark. Edison's invention simply amounts to this: it was known that carbon had a high specific resistance, and that a long thin piece had high resistance; but those who tried carbon found it did not last because, though the reason was little understood then, they did not make good vacuums. Swan has already made carbon incandescent lamps of low resistance, and as soon as heating on the pumps became known, lamps of high resistance came into use. Edison's lamps were not, however, practical even then. Paper is the best of the materials described by him, but it is no use until it is "flashed," and even then it is bad. Silk thread treated by Sidot's process and silk or cotton treated by Sawyer and Man's modification were probably the best materials known at the time; and they would have been very much better than Edison's. Maxim was soon in the field with Sidot's process. He passed gas through the crucible during carbonization. Maxim was also the first to use the modern method of flashing. There is therefore nothing useful or new in Edison's patent. All about high resistance was well known; how to seal into a glass lamp was well known except to Edison; and how to make a reasonably good high resistance conductor was known except to Edison. Edison's patent is also apparently void on the ground of bad faith, though the defendants do not seem to have made much of that. The best, or the least bad, of Edison's materials was paper. Edison knew this, not only before the date of his complete specification, but before he filed his provisional. He had found paper the best on the 22nd of October, and his patent is dated November 10th. Edison patented paper separately afterwards, but that makes no difference. The principle of a patent is that a man is granted a monopoly of a manufacture for so many years in return for introducing a new industry; and he must put the public in possession of what he thinks the best method at the time of the patent, not a few months or a few years after. Edison did not do this. He describes paper quite as a secondary material.

Leaving Sir R. Webster's opening and passing to Sir F. Bramwell, we come to the first extraordinary statement, when that witness states that he never saw a lamp of the same sort as the Newcastle lamp in commercial use or burning at all. Has Sir F. Bramwell never seen a Bernstein lamp? The plaintiffs' witnesses seem to be quite unaware that a low resistance lamp is, as far as the lamp itself is concerned, better than one of high resistance, and that the object of using high resistance lamps is simply to enable the lamps to be run in parallel instead of series. Later on Sir F. Bramwell says the characteristic of Edison's invention is "that it made that which was before an impossibility into a commercial success." Now, lamps made with any of the materials specifically described in Edison's specification have never come into commercial use at all. The first Edison lamps that came into commercial use were, I think, bamboo lamps in 1881, or two years later, when Edison knew how to make more perfect vacuums. No lamps at all have ever come into use with the absurd spiral arrangement which Edison appears to think essential. The same witness says, later, speaking of Lane-Fox's patent, that he knows of "no means in his day of making carbon wire." Does Sir Frederick Bramwell mean to say that prior to Edison nobody knew that a bit of cotton thread could be carbonized, or that arc light carbons could be squirted as thin as desired? He says that in 1878 "no human being, except Edison, knew how to make a carbon filament." If Sir Frederick Bramwell had been well up in lamps, he would have known that strips of such materials as paper occurred to almost everybody who was working at the problem at that time. The whole difficulty then was, not to make a short, thick bit of carbon or a long, thin bit of carbon, but to make a lamp which had a good enough vacuum for the carbon to last in. If lamps were wanted of high resistance, everyone knew at that date that carbon could be made in long thin pieces; even Sir Frederick Bramwell himself had seen charred thread before then: but the difficulty lay in getting a good enough vacuum. A long thin carbon demanded a better vacuum than a short thick one, and unless Edison could show how to obtain a better vacuum than made at that date he could not show how to make a high resistance lamp. If anyone invented a high resistance or filament lamp it was, I think, Swan, who, with Stearn, was the first apparently to make such a thing. Edison did not know how to make a high resistance lamp in 1879; he merely knew that if a lamp was wanted with a high resistance its carbon should be long and thin and should be in a good enough vacuum to be durable. He knew that one step towards a good vacuum was a glass globe. Everybody else appears to have known the same thing, but that does not generally deter Edison from claiming an "invention." He also knew that to make a durable lamp with a thin carbon the lamp should be well exhausted. How to do this he did not know any more than others did. He therefore took out a "fishing" patent for a thing that everybody knew was desirable, but no one, not even Edison, knew how to make.

Dr. Hopkinson said that before Edison, incandescent lighting was impracticable, and immediately after it became an important industry. No doubt it was impracticable before, but so it was after until it was known how to make a good high resistance carbon and how to make a good vacuum. The industry did not develop immediately after Edison's invention, and the development was not due to Edison's invention. Arc lamps have come into use since the days of Noah, but Noah did not invent them. Dr. Hopkinson says he thinks no one knew a filament could be shaped before carbonizing in Edison's time. The same remarks apply here. To Sawyer and Man and to Swan the obvious and natural thing was to carbonize paper. Moreover, little arc light carbons about $\frac{1}{100}$th of an inch thick are made and are now used in some incandescent lamps; these can be bent about before carbonizing. It is to be noted that Dr. Hopkinson, and especially Dr. Fleming, who have had more to do with lamps than Sir Frederick Bramwell, are obliged to admit more on cross examination. Great stress was laid on the question of what was called indifferently "elasticity," "resilience," and "flexibility." A great feature in Edison's lamps was made out to be that he showed how to make carbon that would waggle about. In making an incandescent lamp carbon for a high resistance lamp several incompatible qualities are desirable. The carbon should have high resistance and the usual surface. It should be strong. It should be short and thick, so as not to waggle about or touch the glass. It should, therefore, be of high specific resistance, so that it can be made short, thick and strong, and the material should be hard and durable. It is found that a carbon of high specific resistance is always weak and soft and does not last well, so the high specific resistance has to be given up in favor of a harder material. This necessitates a long thin carbon to get the resistance. The disadvantages of the long thin carbon are that it waggles about and is weak. In fact the very qualities which were brought forward as advantages in Edison's lamp are very serious evils. It is the weakness and tendency to waggle about that form the practical limit of the electromotive force that can be made available. It is chiefly for these mechanical reasons that a low resistance lamp is better than one of high resistance. Swan's was therefore a very much better lamp than Edison's in 1879, being more durable, stronger, and better able to work with the inferior vacuum then in use. Moreover, the fibrous materials chosen by Edison are all bad, as they make weak soft carbon. The expansion due to heating need not injure a straight carbon, as a little spring is then given to the leading-in wires by giving them a bend or fixing them

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at right angles to the carbon. I believe Swan generally used the latter plan. Arched conductors for incandescent lamps were well known at the date of Edison's specification. Dr. Hopkinson says that this ability of Edison's carbon to waggle about allowed it be moved about easily. This is, of course, absurd. No doubt none of the witnesses have seen lamp filaments made as described in Edison's specification. Carbonized thread is about as limp and as weak a substance as you could well have, and paper is nearly as bad. Plain carbonized paper or cotton have no metallic ring, and have not the beautiful properties claimed for a filament. Edison in 1879 did not know how to make a reasonably good filament.

Dr. Fleming said that an ordinary skilled workman could make an Edison lamp. Of course this really means nothing, because Edison did not describe a commercially useful lamp. No doubt if Dr. Fleming had been asked whether an ordinary skilled workman could make a commercially useful lamp from Edison's specification, he would have explained that the materials described by Edison could not be used in a commercial lamp, and that there were no instructions to enable him to make a reasonably good vacuum.

Dr. Fleming said he could call to mind no incandescent lamps that were used practically which contained a rigid carbon pencil or rod. Yet a few evenings before he had attended a lecture where such lamps were shown by Bernstein. He must surely also have seen Gerard's lamps, which have very fine straight carbons; two straight pieces meeting at an angle at the top of the lamp, and being fixed at the other ends to the leading-in wires. These lamps seem to supply the missing link between the filament and the rod or pencil. Later, Dr. Fleming makes out that Sidot's carbon, being a good conductor of electricity, was therefore bad for an incandescent lamp. This would be so if carbon that is a bad conductor were not always soft and weak; the strength is of such great importance that such carbon as Sidot describes would be the best for the purpose. It is always the object of a lamp-maker to get a carbon of as low specific resistance as possible, because it is more durable even when made thin enough to bring up the resistance.

Mr. Imray's opinions have, of course, weight in one direction, as his knowledge of patent law is very deep; but as his evidence was directed to technical lamp work, he was speaking on a subject on which he was no authority. He asserts that all glow lamps now in use are practically of this kind. Does Mr. Imray mean that they have fibrous conductors, or lamp-black putty conductors, or coiled conductors, or high resistance conductors? Whichever he means he is wrong. He again says that Swan's lamp was unfitted for incandescence, and that it did not lead to the practical manufacture of incandescent lamps. Those that know the history of lamps will certainly say that Swan and Stearn and Lane-Fox were the first to make practical high resistance lamps, and that Edison was a long way behind. Edison's lamp did not come into the market at all till he made bamboo carbons. Even now Edison is behind in this matter.

Prof. Dewar's evidence will probably astonish everybody acquainted with the subject. He seems to have carefully not succeeded in making proper carbonized thread according to Sidot's paper. If a carbon is flashed at a low temperature in a rich gas it is rough, uneven, and useless; but everybody knows that a high temperature and small supply of carbon in the gas is needed. Prof. Dewar seems to say that a charcoal conductor would not do because it is a bad conductor of electricity. It is difficult to tell at all from the report what he meant. Cross-examined by Mr. Charles, he says charcoal is not a good conductor of heat "for practical use for the purpose of an incandescent light." What has conductivity for heat to do with the question? Surely the learned professor was talking great nonsense. If not, his evidence should have been valuable to the defendants, for he contradicts Edison's statement that any fibrous vegetable material will do for incandescent lamps. Prof. Dewar also thinks a filament is a fine thread; therefore an ordinary lamp has not what he would call a filament. He goes on to say that a thread carbonized in a hydro-carbon atmosphere, according to Sidot's process, is not electrically continuous, and consists of *petites boules*. One cannot understand what these sorts of statement mean, coming from such a man as Prof. Dewar, and can only say, as they do in the east, "What is all this but bosh? Nothing. The defense seems very feeble, though the counsel made the best of the slender material supplied them. The main points, that a high resistance lamp is as a lamp inferior to a low one; that Edison did not make a more perfect lamp than those already known; and that he merely claimed a thing that was well known to be desirable at that date, but was not practicable till much later, were not insisted upon. The judge was allowed to think that Edison's was the first practical lamp. He says in his judgment that it is quite clear that before Edison no efficient incandescent lamp was known, and that Edison's was the first. The judge points out that there is no evidence that Edison knew of the process of 5,127 when he filed 4,576. Now even if he did not know paper was very much better than thread or carbon putty till December, mentioning the fact in his complete of 4,576 would not have been putting a separate discovery into it. All he had to do was to say paper was the best material of those he described, and not that any fibrous vegetable material would do, or that he used a mixture of tar, lamp-black, and zinc oxide. But Edison did know of this before he filed his provisional. His lordship was also led to suppose that flexibility was a good point and "rigidity tabooed," and that Edison's filaments were very flexible, and strong and durable.

The Swan and Gimingham patents are not discussed because neither is the least likely to be of importance. Lamps can be made quite well without using Swan's patent if it does hold. Gimingham's patent is not used by the Edison-Swan people themselves. They have given up using sockets, and do not cement by Swan's patent, 4,202, 1881, and are using my patent, 1,178, 1884, instead.

The Cheesbrough case is important, but until people can make lamps again the flashing question does not come up. Lamps can be made without flashing, but it is, no doubt, a convenient process.

The first effect of a lamp monopoly will be that prices of lamps will remain high or go higher, and there will be no stimulus to improvement in their quality because there will be no competition. People often grumble at the present price of lamps. Prices have been high because it takes a long time to get a factory into working order, as the making of lamps is new to all the hands, and an enormous amount of experimenting, and that on a commercial scale, is needed before lamps can be made cheap and well. A factory takes about two years to get into swing, but after that lamps can be made very cheaply. The actual labor and material in practice come to about fivepence half-penny per lamp sent out when made on a small scale. These are actual figures. On the scale of manufacture of a large company the lamp should be sold at a shilling or eighteenpence. Incandescent lamp making is troublesome, and there are many mistakes and expensive pitfalls to fall into, but if Edison's was a practical lamp, surely after seven years' practice a company should be able to make lamps of the correct electromotive force and current to order at prices that would put competition out of the question.

ELECTROLYTIC ALUMINIUM.

L. Senet has devised a new process for obtaining aluminium, as well as copper, silver, etc., by electrolysis. He exposes a saturated solution of sulphate of alumina, separated from a solution of chloride of sodium by a porous vessel, to a current of six or seven volts and four ampères. The double chloride of aluminium and sodium is decomposed, and the aluminium is deposited upon the negative electrode.

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CORRESPONDENCE.

NEW YORK AND VICINITY.

The Standard Oil Company to take up Gas Lighting.—Experimental Underground Work.—Burning of the Brush Station on Elizabeth Street.—An Obdurate Blacksmith in Paterson.—New Factory of the Electric Accumulator Company.—The Schuyler Company Arranging to Enter Newark.—Commercial Cable Company Advertising.

IT was reported a year ago that the New York Steam Company had solved the problem of supplying the electric light at a low price by utilizing the waste steam which they have on hand at the close of a working day. The scheme appeared to be very plausible, but there was, evidently, some unforeseen obstacle which prevented its being put into practice. Now the story is, that the Standard Oil Company, which is the supposed backer of the steam company, is to undertake the manufacture and distribution of gas, utilizing the aforesaid waste steam in producing presumedly what is known as water gas, to be furnished, of course, at a low price. Contrary to the practice of monopolies in general, the Standard Oil Company maintains its position after absorbing or wiping out its rivals, by marketing its products at so low a price that no small establishment can possibly compete with it. If it really engages in the gas business, no doubt a similar policy will be pursued, and the only successful way to prevent its establishing a rival system, will be to keep it from opening the streets. Existing gas companies which are pretty well entrenched, will doubtless look after this matter. The street digging evil, however, does not appear to be considered as very serious until the electric companies endeavor to obtain permission to put their own wires underground. It is doubtful if all of them together could become as much of a nuisance in this respect as the steam company has been.

As the time draws near when the subterranean work under the commission was to begin, there is apparently a hitch in the proceedings, which, if very long continued, will throw it over until next spring, at least, for the reason that indulging in experiments will prove to be a very slow process in an undertaking of this character. Lives and property, however, still continue to evade the dangers arising from overhead wires.

The most serious disaster which has overtaken local electric lighting concerns, was the burning of the main station of the Brush company, which is supposed to have been caused by an overheated journal. In this case, it was very fortunate for the reputation of public electric lighting, that an auxiliary station was equal to the burden of supplying the greater part of the street lamps in the district occupied by the Brush company. The heavy loss caused by this fire, suggests the importance of making every possible provision against such accidents in electric lighting stations, as one of the most serious charges which can be brought against any public system of lighting is unreliability.

The Brush company at Paterson, has had rather an unusual experience, caused by the active opposition of a blacksmith named Arnold, to the locating of a pole in front of his premises. The affair finally assumed such importance in the eyes of his neighbors, that a public meeting was held to enlist aid and comfort in behalf of the unharmonious blacksmith. It is fair to assume that the electric lighting business of Paterson will continue to flourish in spite of the blacksmith's opposition, who might more profitably spend his time in shoeing horses than in chopping poles. Let the shoemaker stick to his last.

The Electric Accumulator Company has nearly completed the first factory in this country devoted exclusively to the manufacture of secondary batteries. It is located in Newark, N. J., and is expected to start up next month, giving employment to over 200 hands. The land occupied by the factory fronts 400 feet on Lister avenue, and extends back towards the Passaic river to a depth of 200 feet. At the southwest corner of the lot is a brick office building, three stories in height with basement, with piazzas at the rear of the first and second floors overlooking the river. On the second floor is a dining room and kitchen, and the janitor will occupy the top floor. East of this building is a single story brick building 60 by 40 feet, which will contain the machine and carpenter shops, and the dynamo, store and shipping rooms. In the rear are the engine and boiler rooms 40 by 60 feet. There are three large boilers and a Watts-Campbell double engine of 200 h. p. A frame building 200 by 35 feet extends along the avenue to the works of Lister Brothers, in which will be the forming, lead burning and other departments. A branch of the Central Railroad of New Jersey runs close to the front of all the buildings. Theodore N. Vail is president, and O. E. Madden, vice-president of the company.

The Schuyler Electric Light Company has made application to the Newark common council for permission to erect poles in the streets. Dr. F. B. Mandeville, who represents the company in that city, says it is their purpose to introduce a superior light at the same, or possibly a lower price than is now paid. At present it is proposed to introduce it through Roseville, the 11th and 13th wards, and vicinity, which districts are now very sparsely lighted with gas. The city contract with the present company has two years yet to run.

If the Commercial Cable Company fails to achieve success, it will not be for lack of advertising. The *Herald* surrenders valuable space daily in both editorial and news departments to booming the enterprise. A quarter of a column in *italics*, kept standing on the editorial page, devoted to the details of a "race message" with the old companies, is a favor which no other company would be likely to obtain at any price. The other dailies, with certainly one exception, also give editorial endorsement to the Mackay-Bennett cable, and as the advertising of such companies is not freely indulged in when it must be paid for at regular rates, it is evident that it must be more than ordinarily effective. The peculiar character of cable telegraphing enables the managers to determine very readily which is the best paying rate, and future reductions will depend in a great measure upon the increased carrying capacity of the cables, which will eventually be attained by improved methods of transmission.

NEW YORK, August 23, 1886.

PHILADELPHIA.

Consolidation of Electric Light Interests.—Electro-Pneumatic Transit Company.—B. & O. Telegraph Co.—Report of Chief Walker of the City Electrical Department.

THERE is a rumor afloat that arrangements have been in progress for some time past for consolidating the interests of the leading electric light companies in this city, and merging their business into one corporation. Among the companies spoken of in this connection are the Brush, United States, Northern, Thomson-Houston, and Philadelphia Sectional Underground, the latter using the Excelsior light. The terms of consolidation have not been ascertained, and considerable time has been required to obtain the assent of the stockholders to the plan. Investigation fails to connect this rumor with anyone authorized to speak about the matter, so that I presume it may be set down as "mere talk."

Ex-chief of police, Givin, has been made manager of the working capacity of the plant and contingent energies of the Electro-Pneumatic Transit Company. Mr. Givin has been the manager of the American District Telegraph Messenger Service. The Electro-Pneumatic Transit claims to send messages and packages, legal documents, etc., etc., through underground tubes, with speed, safety, security and cheapness, and it is claimed will eventually revolutionize the old carrying methods.

The property and franchises of the B. and O. Telegraph Co. in Pennsylvania were recently sold at a meeting of the stockholders to the Baltimore and Ohio Telegraph Company for the purpose of consolidating the latter's interest in the state, and adding to its efficiency.

"Philadelphia obtains electric lights cheaper than any other large city in the country," said chief Walker of the Electrical department, in speaking of the apparent increase of 400 per cent. in the appropriations to his department during the past three years. "The average cost is less than 55 cents per night a lamp, and the truth is most of the companies that do lighting for the city lose money by it. Many of them make their figures very low for the privilege of being allowed to place their wires upon the city poles, and cover their loss in the charges to private customers. There are 352 lights paid for by the city, and they cost $10,000 less than they would in most other cities.

"As to the expenses of the department, the increase since 1884 is more apparent than real, and what there has been is for improvements rather than maintenance. The appropriation for 1884, when we did not have charge of the electric lighting, was $35,000, and in 1885, when it was transferred to us from the police department, the appropriation was $84,467. Although I asked for $178,114 for 1887, I do not suppose I will get that much. This year we had $104,995. Of this $70,664 is for the maintenance of lights already up, and I have asked for $25,000 for new lights next year.

"The odd $70,000 is divided among a number of companies whose prices for lamps vary. Thus the Brush company receives 52 cents a night for its lamps on Chestnut street, 58½ cents for those on Poplar street, and 55 cents for those on Lancaster avenue. The United States company is paid 48 cents a night for its lamps on North Broad street, 59½ cents for those on Delaware avenue, and 62 cents for those on Federal street. The Northern Electric Light Company obtains only 39½ cents for four lights on Second street, above Callowhill, as the wires are strung on city property. It is paid 48 cents for its lamps on Girard avenue. A company in Frankford, whose lights only burn half the night, is paid 30 cents a lamp. In Germantown the price is 55 cents. The Thomson-Houston company, whose lights are on Columbia avenue is paid 48 cents a night. The average price for all the lamps is, as I said, less than 55 cents a night apiece.

"The cost of an electric light depends upon the number of lamps on a wire, the distance from the source of supply, and other considerations. It is because of the greater distance that

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the United States company charges 62 cents for a lamp on Federal street, while for those on Broad street it asks only 48 cents. The distribution of the lamps is, of course, a matter resting entirely with the city councils. It is only my duty to put them up where they are ordered.

"The operating expenses of the electrical department have increased very little, not over $4,000, since 1884, notwithstanding the great amount of extra work we have had to perform. The number of fire-alarm boxes has increased from 150 to about 500 within that time; the fitting-up of the police patrol service has been put upon us; telephones have been placed in all the fire-engine houses and hospitals, and many improvements have been made. Certainly the expenses of the electrical department cannot be complained of as extravagant."

PHILADELPHIA, Aug. 18, 1886.

BOSTON.

Lightning Strokes.—Concord School of Philosophy.—New Railway Signals.—Telephone Closets Make Opportunity for Thieves.—Gas and Electric Light.—Telephone Output of the American Bell Telephone Co.—Electric Lights in Beverly.—Fire Alarm at Hyde Park.—Electric Light at Salem.—New England Telephone Co.'s Dividend.

THIS is the time of the year when the stream of electricity runs low, so far as news concerning developments and applications of that useful force are concerned. It is a month when nature resumes her old time sway of the elements, and displays her exhibitions of electric lighting, which, while they last, surpass the feeble efforts of man. There have been in New England, several fatal cases of lightning strokes, and some property has been destroyed; though, as yet, the cases have not been as numerous as last year.

Now, if the readers of this journal were interested in the discussions of the Concord school of philosophy on "Dante's Convivo", in which he wrote a series of papers to the new lady of his love, the lady of philosophy, or the discussions on "Dante and Beatrice," or of the "Purgatorio," in which the modern Greek wrestlers strive to display the acuteness and agility of their minds, I could fill an even page, if helped out with scenes from the latest Chinese murder, the late heavy embezzlement, or how the Boston base ball nine was whitewashed (the latter would hardly be suitable for a "news" column), or an account of the present labor trials.

But unfortunately it would not be just what is wanted, although lots of discipline for the mind would result from lively discussions on the "thusness of the when," and those other entertaining matters which absorb the minds of the Concord philosophers. Nothing succeeds like success, and so every good thing is sure to be followed by others. This is well illustrated by the success of the Judkin railroad train signal, which has been put on a large number of the railroads of New England; for here comes a competitor in the race for the business.

A party of gentlemen, directly and indirectly interested in the workings of a new automatic signal for railway trains, took a train on the Fitchburg railroad the afternoon of the 15th inst., for the purpose of seeing the practical working of the invention. The two o'clock train from Boston was equipped with the invention, called the "automatic electric signal, a system of electrical communication between the conductor and the engineer." In the party were a number of railroad men, who seemed very favorably impressed with the workings of the signal, and who had the opportunity of closely studying its operation and of questioning its inventors, Messrs. Charles H. Magoon and George D. Burton.

A description of the system used would show it to be a simple yet sure method of doing away with the bell cord. The object of the invention is to enable the conductor to signal the engineer by means with which each car of the train is provided, and which do not require to be provided with separate couplings between adjacent cars. This is accomplished by utilizing the couplings of the various automatic air brakes and their connections, so that no additional labor is required to make electrical connection throughout the train, as the circuit is instantaneously and automatically completed by coupling the air brakes together. The electrical current is produced by six Leclanché batteries, which are hermetically sealed and placed in a suitable box, which is carried on the train, thence connected with the bell in the cab. No bell cord connects the engine with the first car, and there is no cord connecting the cars of the train. The slightest pull on the cord running through a car causes a ringing of the bell in the cab. The advantage of this new system is seen in various ways. Should a train break into two or more parts the circuit is, of course, broken, causing the bell to ring continuously until the cars are again united, or the engineer stops the alarm by closing a switch near his seat in the cab. In going around a curve in a long train it is almost impossible to ring the bell in the cab by pulling the old time bell cord in one of the rear cars. This new arrangement works on all curves and in the longest trains.

This device has been used on the Fitchburg road for six or seven weeks, and is working admirably. The cost of applying the signal to a car is very small, and the advantages are many in number. An engineer of a train provided with this device is warned when his train starts if the couplings are wrong. This, in itself, is quite an improvement. The invention is one that will stand investigation, and will, undoubtedly, in a short time, be in use on all the go ahead roads in the country.

For the purpose of equipping railroad trains with the device, a corporation called the Automatic Electric Signal Company, has been organized under the laws of the state of Maine, with a capital stock of $100,000. Mr. Magoon is president, and Mr. Burton secretary and treasurer, and the directors consist of Messrs. John H. Fox, of East Jaffrey, N. H., and Luther F. Lewis, Murray V. Livingstone and J. T. Wilson, of Boston. Messrs. H. G. Coming, of Boston, and Charles E. Barber, of Washington, D. C., are the counsel.

Users of telephones who have a nice, quiet and snug little closet, where they retire to converse in secrecy with their friends, would do well to leave some one on guard while so doing. A gentleman on Washington street, while engaged at his telephone, had a money draw rifled of quite an amount of money.

I have been at some trouble to obtain information concerning the action of the gas companies in this state, securing legislation allowing them to put in electric lights in connection with their established business, and in recent communications have given the results. I regard the actions of the gas companies as significant of the march of events, showing that they want to give the public what is wanted. Yet it may be true, as has been charged in some cases, that the gas companies simply desire to secure rights and privileges to keep them from the regular electric light companies, and not be in a hurry to use them themselves. The board of aldermen on the 19th inst., passed an order to permit the Charlestown Gas Company to erect poles for electric lights in Charlestown. The net output of instruments by the American Bell company, for the month ending July 20th, was 1,897, against a net loss of 314 for the same month last year, or an increase of 2,211. From December 21st to July 20th, the net output has been 14,270 against 5,398 same time last year, an increase of 8,872. To show the changes incident to the business, it may be said that the net for July was the result of putting out 3,279 instruments and having 1,382 returned; while from December 21st to July 20th, 24,914 instruments were put out and 10,644 returned. The result, however, is very satisfactory, and shows the continuous growth of the telephone in popularity.

The reorganization of the Sun Electric Light Company of Woburn, was completed on the 23d inst., when the following-named officers were elected: President, William Butterfield, of Boston; treasurer, Frederick Swift, of New Bedford; secretary, Lyman P. French, of Boston; directors, William Butterfield, Isaac Fenno, F. A. Gilbert, Lyman P. French, Frederick Swift, Nathan J. Simonds, Marmaduke M. M. Slattery. The capital stock was increased to $500,000. It is understood that as soon as the necessary facilities for manufacturing can be made, there will be upwards of 175 hands employed.

Electric lights are being located in Beverly for street illumination. A number of business places have contracted for the lights.

The committee on fire alarm at Hyde Park has awarded the contract for putting in the poles and stringing the wire, to Mr. Bly of 37 Pearl street, Boston, with the condition that the work shall be completed in 30 days. There will be 10 miles of wire, with fire alarm boxes. The contract for furnishing the latter has been awarded to George M. Stevens. There will be a gong at the engine house, and the other boxes will be at Clarendon Hills, Readville, Fairmount and the Greenwood district.

The contract between the Electric Light company and the city of Salem for furnishing 104 street lights to burn every night in the year was signed on the 27th inst. The lights are to be ready and burning Oct. 1st, and will burn all night. It is thought that they will supplant 255 gas lamps. The cost per year is between $17,000 and $18,000. The contract is to run two years from Oct. 1st 1886. The city now has 489 gas street lights and 519 oil lamps. The cost of the street light department is $21,000.

The announcement that the New England Telephone Co. directors had declared a dividend of only ¾ of one per cent., has caused considerable dissatisfaction among the stockholders in Lowell. When the compromise was effected between the New England stockholders and the Bell company, it was understood that a 3½ per cent. dividend per annum was to be paid. This would require a 1 per cent. dividend now, and a meeting of stockholders to ask the Lowell directors why this is thus, is likely to occur. To *other* stockholders, who rejoiced when the power was taken from the fellows, principally from Lowell, who had nearly wrecked the whole property, this is arrant nonsense. There are people who see that the property is rendered more valuable by a conservative policy, and that their stock is a better investment thereby.

BOSTON, August 16, 1886.

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CHICAGO.

Sinking of the Oregon.—Aeronautics.—Prof. Carhart's Change of Location.—Pan-Electric and Other Telephones in the West and South.—Underground Wires.

DURING the period of uncertainty as to the cause of the loss of the Oregon, a theory came to the surface, which might possibly explain a similar accident, but the agency suggested would leave so little track behind it as to make the proving up of the cause quite difficult.

The assumed cause of such an accident is a stray torpedo. Torpedoes are an erratic kind of ammunition anyhow, and if one of the variety prepared with a percussion cap upon the forward end, should miss its mark on being fired at a target, what is to prevent it floating about in the ocean, drifted and carried by the gulf stream, deep enough to prevent its being seen from the surface, yet not too deep to be struck by a first-class steamship. An iron bottomed vessel striking the business end of such a torpedo, might just as easily explode it as a plow might ignite a bomb that had lain in a cotton field since the war; an occurrence which the press has once or twice chronicled during the last few years.

Dr. A. de Bausset, of Chicago, has most magnificent ideas of aerial navigation. He has figures carefully prepared by able mathematicians verifying the premises assumed, and showing that it is perfectly feasible to navigate the air in any direction at will, with a machine of such dimensions as will render the transportation of not only passengers but freight, a successful money making business. The principle on which the doctor is banking is an entirely novel one. He purposes discarding buoyant gases, and using in lieu of these, an exhausted cylinder of steel, formed of plates fish-jointed, and of about one-fortieth of an inch in thickness, stayed and braced at the joints, and stiffened by radial ribs within. In addition to this, discs will divide the cylinder, which is cone pointed at either end, into independent compartments, so that this distribution of weight is available in steering the balloon upward or downward. The specific weight of the atmosphere at sea level is about two and two-thirds pounds per cubic yard. The capacity of the cylinder proposed would be such that it would have a lifting power of some 815,000 pounds. Taking the weight of the machine—the cylinder is to be six hundred feet in length and one hundred in diameter—with all its attachments, electrical motors, etc., etc., the doctor claims a residual useful power of buoyancy equal to one hundred and fifty tons. Exhausting the air from the cylinder, of course, will lift the balloon, while permitting the air to fill the space will, of course, increase the weight of the apparatus. With a gas balloon, once the ballast has been all thrown out, no further rise is possible, while on the other hand, once the gas is permitted to escape, to help aid a descent, there is no recovering that amount of buoyant power. With a vacuum these interchanges can be made and repeated at will. The steering apparatus, too, is to be handled by an electric motor, and will direct the air ship in any course, either laterally or vertically as may be desired. Just as soon as the one thing needful can be brought into the coffers of the company, a model of smaller dimensions is to be built, to show the De Bausset invention, when, if it proves a success, there will be no difficulty in organizing and equipping a road which will have no grades, no tunnels, no crossing signals, no switch-plates; the cars on which will

> "Fly through the air as the bird may fly,
> Or a meteor flits through the midnight sky."

Prof. H. S. Carhart, recently professor of physics in the N. W. University at Evanston, has been called to, and has accepted the similar chair at Ann Arbor, Michigan, in the State University. The professor was chosen to the position by an unanimous vote, and was in town a few days since bidding his host of friends here good bye. Evanston's loss is Ann Arbor's gain, and while we shall miss the professor on his days off, we can but congratulate him and his new friends and co-laborers on the change of fealty.

Nearly all the anti-Bell telephone companies throughout the west and south, having had the seal of the courts placed upon their lips, we hear very little now-a-days about a company which is desirous of having a legal knock-down with the Bell company. All who were really anxious seem to have got all their aprons will conveniently cover, and the race of telephone inventions which do not interfere with the Bell, or do not infringe, or are patterned after the Reis, or the goodness knows what, seems to be rapidly running out. It is astonishing what a dampening effect the decision of the New Orleans court, when it smashed the pet idea that because the Bell company was on trial it was necessarily guilty, had on the patriots who desired to sell stock and start exchanges which could not be enjoined until after the long winded trial should have been finished. It brought the theory out in full blossom, with glowing colors, but it knocked the poetry out of it, and left it standing quite naked to cold blasts, and in the "keen bright light of publicity."

A year or so ago, New York had a sort of sanitary spasm over the malaria, which would be brought to the surface whenever the ground should be broken for underground wires. The commissioners appear to have taken but little stock in that kind of a scare, and are going right along with their little grave digging. The theory fell flat, and has not been heard of since the law was passed. Here in Chicago a great mistake was committed in digging for the underground work before the theory was discovered. As a consequence we have had our streets in a horrible condition of tear-up for the past two years, and to-day they are furrowed for gas pipe, plowed for pavers, dug and ditched and delved in, until one can see a lot of fellows on almost every street doing something in the way of tearing up or replacing a street or an alley or a pavement; and yet the doctors for the most part are off on their summer vacations while the remnants of the craft are lying around their offices and growling at the alarmingly healthy condition of the city.

The malaria fake was born too late for Chicago use.

CHICAGO, Aug. 14, 1886.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICIAN AND ELECTRICAL ENGINEER, 115 *Nassau Street, New York city.*

"THE BUG IN THE QUADRUPLEX."

[58.]—There have recently appeared in the columns of your very valuable publication two communications in regard to the "Bug in the Quadruplex." Not being fully in accord with either of the writers in regard to the subject under discussion, I would like to add a few words, though at the risk of contributing nothing in the shape of ideas.

First, in regard to Mr. Field's statement that the battery reversals at the distant end do not perceptibly affect the home neutral relay, Mr. Maver has, I think, shown this to be an error, but if Mr. Field will some time ground the home end of a wire through an ordinary neutral relay, he will probably have no difficulty in detecting any battery reversals from a quad set at the other end, proving, it would seem, that the disturbance in the quad relay is at least not entirely due to condenser complications; and, further, if the condensers are so adjusted that their charge offsets that of the line, will Mr. Field explain why, when a mutual earth is provided on the pole-charger points coming together, the line discharge does not neutralize the effect of the condenser discharge. I heartily agree with Mr. Field that the less variation there is in the resistances the better the results. Upon long lines of considerable capacity the tendency of the line and condensers to discharge when the pole-changer points all come together makes bad sparking at the contacts, and a means of reversing a low resistance battery without fusing the contact points would be of great practical benefit.

The "bug" matter seems to me to sum itself up about as follows:—

In a well insulated line of convenient length the Edison arrangement is very efficient, but with a long wet line it is usually difficult to obtain a balance which will show perfect equilibrium of the home relays whichever pole of the battery is to line. It is, therefore, often necessary to maintain a small amount of tension on the retractile spring of the home neutral relay to offset the defective balance. Another effect of the leaky line is to diminish the strength of the arriving signals, and the working margin of the neutral side must necessarily be the difference between the arriving strength of the signals from the two sections of the distant battery, *minus the extra tension of the home neutral relay spring.* This frequently leaves, in practice, sufficient variation to produce good signals while either pole of the distant battery remains to line, but the interval of no magnetism, mentioned by Mr. Maver, comes into marked prominence the instant the distant battery is reversed, and the Edison device does not entirely suppress the effect. Were it not for the fluctuation in the magnetic pull of the home neutral relay during a reversal of the distant battery, the neutral side of many quads now abandoned in wet weather could be made more or less useful, and therefore the "bug" is, in my opinion, a defect.

New York, Aug. 4, 1886. MINOR M. DAVIS.

CATALOGUES AND PAMPHLETS RECEIVED.

The Star Iron Tower Company, of Fort Wayne, Indiana, issue the second edition (1886) of their American Electrical Directory. The directory is particularly useful to electric lighting interests. In a shapely and well printed volume it affords a collection of much important and useful information, including an alphabetical list of officers of electric light companies, lists of manufacturers of electric light apparatus, of contractors for electric lighting, of isolated and

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central electric light plants, and reports of electric lighting companies arranged by states. The volume cannot fail of being useful to the large number of people now engaged in various ways in the growing business of electric lighting. The directory also devotes considerable space to the subject of motors and the electrical transmission of power. A further useful feature is a list of abstracts of electric light patents of 1885.

A. K. Eaton, 65 Henry street, Brooklyn, N. Y., issues a catalogue and price list of instruments for electrical measurement. Improved prisms, spectroscopes and spectroscopic appliances, telescopes, microscopes, achromatic objectives, etc. The list includes description of many of the instruments offered—including the ammeters, voltmeters, and voltammeters, manufactured under Prof. Eaton's patent of January 21, 1884.

The Wainwright Manufacturing Company, 65 and 67 Oliver street, Boston, send us their catalogues of Wainwright heaters, filters, corrugated tubes and expansion joints, including descriptive matter of interest to users of steam and water.

ELECTRICAL NEWS AND NOTES.

TELEPHONE COMPANY OF PARIS.

The present telephone system was established in 1878, and the organization is of the most rudimentary nature, and utterly inadequate to keep pace with the ever-increasing demand for efficient telephone service. M. Gravet proposes that the exclusive right for carrying on telephone work shall be granted to a company which shall farm the telephones for 35 years. The company must buy up all telephone installations already existing. The work shall be carried on under government inspection, and for this purpose a comptroller-general shall be appointed. The company farming the French telephones shall be bound to place, free of charge, telephone instruments in all the communes of the republic which are unprovided with telegraph offices. At present nearly all cantonal centres have a telegraph office, which, as a rule, serves four or five communes, to which telegrams are carried by express messenger at an extra charge of 50 centimes per kilometre, a heavy additional expense to the cost of a message; and so slow a means is this of forwarding telegrams, that the post is generally made use of in preference. These drawbacks would be avoided by the new scheme.

It is proposed that all communes, on application, shall be directly joined by a telephone line to their cantonal centre or to the nearest telegraph office. The farming company will supply the transmitting instruments, and the communes will only be subject to the cost of the line, which will be constructed for them by the government at the charge of 100 francs per kilometre.

With regard to the large towns, there will be a notable improvement in the means of communication through the new system. For instance, in Paris at present, the only office at which a telegram can be sent during the night, is the central office at the Bourse, a serious inconvenience to those living at a distance. M. Gravet's scheme will enable the public, at any hour of the night, to hand their messages in at the nearest telephone office, whence they will be sent to the central office to be forwarded thence in the ordinary way. *Vice versa*, a telegram arriving at the central office will be sent to the telephone office of the quarter in which the destinaire lives, and an official of the company will immediately take it to the address.

The telephone subscription will also be reduced to 600 or 400 francs for Paris, and to 400 or 300 francs for the provinces. These figures will be further reduced so soon as the company makes a certain profit on the work.

The lines established for government work shall have a reduction on these figures of 50 per cent., and a reduction of 25 per cent. shall be given to those for departmental service. If the farming company makes a profit of more than 6 per cent. on the capital employed the government shall share in the excess to an extent of 15 per cent.

The company binds itself to repay the government all the expenses the latter has gone to in constructing the lines now worked by it, and to buy, for the future benefit of the government, the systems worked by the Société Générale des Téléphones.

The company binds itself to redeem its share capital of 25 millions (francs) during the duration of its concession. At the expiration of the 35 years the government shall come into possession of the whole of the company's systems without having to make any payment whatever.

When the capital has been completely utilized the government can oblige the company to obtain fresh resources for the extension of the telephone system. This will be done by means of bonds; the value, duration, and manner of redemption, being determined by the government.

The government has the right of intervention in the appointment of the company's officials, and in the control of the company's accounts. For the latter purpose a committee will be appointed by the government, the company being obliged to pay all expenses connected with this control.

The construction of the telephone lines will be carried out by employés and with material selected by the government, at the expense of the company.

In case of war, or in any exceptional condition of affairs, the government can suspend the telephone service without incurring any liability towards the company or the subscribers.

At the end of the first ten years of working, the government has the right of buying back the concession at a price to be fixed upon by a committee of experts.—*Electrical Review* (London).

RESULT OF THE CABLE WAR.

The directors of the Anglo-American Telegraph Company have issued a report to the shareholders, July 22, which contains the following statements:

"The reduction of the tariff from 2s. to 1s. 8d. per word, introduced by the Commercial Cable Company on Dec. 24, 1884, resulted in a large decrease in the gross revenue produced by Atlantic cable traffic. Nevertheless it was determined by the associated cable companies to give the reduced tariff a fair trial, in order to avoid a war of rates, and to determine as early as possible whether the reduction would result in any remunerative increase of traffic. After more than a year's trial it was found that the very contrary was the case, and as the rival company resorted to means to obtain a greater share of the traffic than the possession of two cables fairly entitled them to, the directors of the associated companies came to the conclusion that it was necessary, in the interests of their proprietors to adopt a low rate.

"Accordingly on the 5th of May, 1886, the rate was reduced by the associated cable companies to 6d. per word, and by special arrangement with the Western Union Telegraph Company of America, this tariff was made to extend to all the principal cities and towns in the United States and Canada. For press news a special rate of 3d. per word between London and New York was also adopted. On the same date the tariff of the Mackay-Bennett cables was reduced to 1s per word. The effect of this important reduction of rates by the associated companies has been a very considerable augmentation of the traffic, much larger, indeed, than was anticipated as a first result, amounting to over 110 per cent., and although the total receipts have greatly decreased, the company is earning sufficient to pay its working expenses and to place such a sum to the credit of the renewal fund as, with the accruing interest, will soon bring that fund up to £1,000,000, the limit fixed by the proprietors at the last half-yearly meeting.

"The unexpected increase in the volume of traffic immediately upon the introduction of the sixpenny tariff has induced the directors to consider the expediency of adopting permanently a system of low rates. The associated companies possess between them no less than eight cables across the Atlantic, having a carrying capacity which, for practical purposes, is unlimited. With such an extensive system it is obviously their interest to encourage a very large traffic at low rates, and by so doing prevent a further multiplication of unnecessary cables. By the recent reduction of rates, cable customers and the public have the opportunity of answering the question upon which the future rate between Europe and America will have to be decided, namely, whether there is a sufficient inherent development in the cable traffic to and from America to warrant a low charge being permanently established. If there be such development and the public respond to the desire of the associated companies to continue working at low rates, it will be to the interest of the companies to do so, as they only desire to earn a reasonable return upon the capital invested and prevent further wasteful competition. The directors would remind the proprietors that the company has now been in existence for over 20 years, and that, although, high rates were in the first years of the undertaking an absolute necessity, and were not at the time objected to by any important class of the community, it has since been found that whenever they were adopted the result was continuous competition, useless multiplication of cables, and loss of money to all the companies interested. The directors believe that sooner or later a low tariff will be a necessity, and that by 'taking time by the forelock' and making an earnest effort now to establish it they will secure the cordial approval and co-operation of their customers and the public, without which so important a step could never be successfully adopted."

THE RHODE ISLAND CLAMBAKE OF 1886.

The annual gathering of the electrical fraternity as the guests of the American Electrical Works, at Providence, on Aug. 20th, was most enjoyable in every respect. The invitations which had been generously scattered through the country, were very fully responded to, either in person to the number of 126, or by letters of regret from perhaps 50 more. The resources of the designer had been once more most successfully devoted to the production of a novel invitation card, it being this time a very perfect counterfeit of a soda cracker, and many gentlemen receiving them had endeavored to convince their wives that they were a new sample of that article, and were apparently astonished by the frank criticism that they were "too tough." If not food in themselves, however, they were satisfactory credentials for participation in a regulation Rhode Island clambake, served up in due and ancient form by Tom Rhodes on the banks of the romantic Pawtuxet. At the hour of 10 A. M. on August 20th, the first installment of the guests had assembled at the Providence telephone exchange,

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A little time had been consumed in the purchase and preparation of "chestnut" bells, many years experience having pointed out the importance of possessing some means of suppressing ancient and threadbare anecdotes, obtuse puns which required explanatory notes, and songs which were made up by sundry repetitions of a single verse, and usually pitched at an unattainable key. A snare drum was engaged especially for the use of an eminent electrician who had asserted his ability to execute "reveille" and "double drag." One feeble attempt with the sticks convinced him that he had lost his grip, and various members of the party during the day volunteered to show what they knew or did not know about drumming. The first load of 40 in a four-in-hand "barge" left the exchange at 10:30, and after a drive of about an hour was landed at the scene of the festivities. Other loads came down during the day bringing delegations from various points. Providence was strongly represented, it having been reported that the grounds would be exempted from the stringent exactions of the new prohibitory state law. Although a never failing punch bowl was provided, it was visited with extreme moderation, and served as a very appropriate accompaniment to a substantial lunch which awaited all new arrivals. The necessary implements had been provided for organizing rival sports, and the devotees of base ball, rifle shooting and archery were soon deeply interested in their respective events. The various experts were frequently discomposed by the sudden descent of a football which appeared to be strongly attracted by high white hats Just before dinner the entire assemblage was grouped on the shady side of the house and an excellent photographic negative taken.

A larger number than was expected sat down to enjoy the shore dinner, at 3 o'clock, when the genial host, president Phillips, introduced ex-governor Howard, who extended in his behalf a hearty welcome to the guests who had assembled for the eighth time to enjoy Rhode Island hospitality.

The *menu* card was another gem in the line of unique stationery, being a miniature slate with sponge and pencil attached, on which were a series of schoolboy sketches entitled "The man and the clam—the clam sees the man, and the man seizes the clam." The fertility of invention displayed in Rhode Island in serving up clams, with literary and æsthetic accompaniments, is apparently as inexhaustible as the clam crop itself. The dinner was of the orthodox character, clam chowder, bluefish, clam fritters, baked clams, green corn, cucumbers, tomatoes, watermelon, indian pudding and coffee, and was heartily appreciated as a most welcome change from the ordinary formal dinner of civilization. After dinner the popular out-of-door sports were resumed, until five o'clock, when the various guests began to scatter to return to their homes, eminently pleased with the day's experience. President Phillips has been exceedingly fortunate in selecting the dates for these gatherings. As on all previous occasions the weather was simply perfect.

The following is a complete list of those in attendance :

Adams, Geo. J.. Providence, R. I.
Adams, Geo. W., Boston.
Addeman, M., Providence, R. I.
Anderson, Jno., Binghamton, N. Y.
Backus, E., Boston.
Baker, C. O., Jr., Newark, N. J.
Baker, E. B., New Haven.
Barton, S. E., Boston.
Beckford, E. S., Boston.
Beetle, Geo. L., New York.
Belcher, John E., Providence, R. I.
Bly, Chas. L., Boston.
Blodgett, A. D., Boston.
Boynton, F. J.. Boston, Mass.
Bradford, H. C., Providence, R. I.
Breckenridge, H. W., Providence, R. I.
Brophy, Wm., Worcester, Mass.
Burdon, L. L., Providence, R. I.
Burgher, Chas., Boston.
Burnham, Geo. H., Providence, R. I.
Bullock, C. H., Pawtucket.
Buswell, F. C., Providence, R. I.
Carhart, E. M., Providence, R. I.
Carpenter, C. M., Providence, R. I.
Carroll, J., Newport, R. I.
Carter, C. H., Brooklyn, N. Y.
Chace, J. H., Providence, R. I.
Chester. W. F., Boston.
Clarke, J. H., Boston.
Clarke, L. W., Providence, R. I.
Cleverly, H. A., Philadelphia.
Cozzens, H. W., Newport.
Cranston, H. C.. Providence, R. I.
Crofut, W. S., New Haven.
Daboll, F. G., Springfield, Mass.
Darling, J. O., Providence, R. I.
Davis, A. F.. Providence, R. I.
Dempster, W. W., Providence, R. I.
Doolittle, T. B., Bridgeport, Ct.
Douglas, C. H., Providence, R. I.
Drake, D. E.. New York.
Drake, Jno. I., Providence, R. I.
Duxbury, J. W.. Providence, R. I.
Fahey, P., Boston.
Fuller, C. H., Providence, R. I.
Fyler, E. W.. Providence, R. I.
Garratt, A. V., Boston.
Hamilton, G. A., New York.
Hanson, Geo. E., Somerville, Mass.
Harris, H. H., Providence, R. I.
Hathaway, W. A., Providence, R. I.
Hayden, D. F., Providence, R. I.
Hill, W. S., Boston.
Howard, C. T., Providence, R. I.
Howard, E. H., Providence, R. I.
Howard, H., Providence, R. I.
Hoyt, G. W., Danbury, Ct.
Hoyt, J. F., Greenfield, Mass.
Hughes, C. T., New York.
Hull, F. A., Danbury, Ct.
Hurlbut, P. J., Providence, R. I.
Hyland, J. T., So. Framingham. Mass.
Jaques, John T., Providence, R. I.
Keenan, W. J. Boston.
Kilbourne, H. W., Providence, R. I.
Knight, R. O , Providence, R. I.
Knudson, A. A., New York.
Langstaff, H. C.. Providence, R. I.
Le Mitchell, D., Taunton, Mass.
Lillie, N. W., Boston.
Lincoln, Chas. E., Providence, R. I.
Lowe, Edwin, Providence, R. I.
Millard, G. W., Providence, R. I.
Millen, H. J., Boston.
Miller, A. S., Providence, R. I.
Mitchell, D. L , Taunton, Mass.
Munroe, W. N.. Providence, R. I.
Nason, P. C., Santo Domingo, W. I.
Payson, S. R., Providence, R. I.
Peckham, F. H., Jr., Providence, R. I.
Perkins, E. C., Providence, R. I.
Peterson, C. G. A., Providence, R. I.
Pettengill, H. J., Boston.
Phillips, E. F., Providence, R. I.
Pope, H. W , New York.
Pope, R. W., New York.
Porter, Geo. F., Pittsburgh.
Price, C. W., New York.
Rand, C. W., Boston.
Remington, C. R., Jr., Providence, R. I.
Ridlon, Frank, Boston.
Robertson, Geo. M., New York.
Royce, F. W., Washington, D. C.
Sawyer, W. H., Providence, R. I.
Scales, W. S., Boston.
Schaefer, F., Boston.
Schmidt, A. L., Louisville, Ky.
Sears, E. S., Boston.
Sheehan, C. J., Boston.
Shepardson, A. C., Waterbury.
Sherman, H. H., Providence, R. I.
Sherman, W. R., New Bedford.
Simons, Mark, Boston.
Sims, G. C., Providence, R. I.
Sinclair, H. A., Brooklyn, N. Y.
Slattery, M. M., Woburn, Mass.
Smith, E. A., Providence, R. I.
Smith, Gerritt, New York.
Stedman, W. H., No. Adams, Mass.
Stevens, N. H., Hartford.
Storr, C. H., Lexington, Ky.
Stump, C. E., New York.
Sylvester, Chas., Fall River.
Thomas, V. A., Providence, R. I.
Thornberry, H. S., New York.
Weeden, C. R., Providence, R. I.
Wheeler, A. D., Boston.
White, A. C., Providence, R. I.
Whittier, R. M., Providence, R. I.
Wright, Augustus, Providence, R. I.

THE PATENT OF E. A. EDWARDS FOR TELEGRAPH INSTRUMENTS SUSTAINED.

On July 8, 1886, Judge Brown of the Southern District of New York, delivered his opinion in the suit of George W. Larne *v.* Western Electric Company, for alleged infringment upon the patent of E. A. Edwards, of January 16, 1883, for an improvement in telegraph transmitters, which consists essentially in suspending the lever by a torsional spring instead of the trunnions ordinarily used. Owing to the length of the opinion we can only give a summary of the principal points. After explaining the construction and uses of the telegraphic key and sounder, the Judge says :—

"The use of a torsional spring by means of a flat strip of metal "secured at both ends is not indeed wholly new. It appears to "have been devised for use in certain parts of clock-work some "fifteen years ago, but to what extent actually used does not ap- "pear. It is not shown, however, to have been previously ap- "plied in the manner designed in this patent, nor in combination "with a lever or bar fulcrumed upon the metallic strip, and de- "signed to serve at once as a torsional spring and as a substitute "for the use of pivots or trunnions, with or without retractile "springs. It is this combination that is patented. It is "evidently useful, economical and valuable. As a combination, "it was new, and in my judgment the patent is valid. An in- "spection of the sounder in question leaves no doubt that it em- "bodies the Edwards invention, nor that it appropriates this "combination and the whole of it."

He describes the defendant's sounder, showing the mechanical functions to be the identical Edwards combination, and that the retractile spring is immaterial. Then he considers the claims, and says that the sounder by numerous decisions is not an infringement of the patent so far as the patent rests upon the first, second and fourth specifications of the claims. Then he considers the third claim at length, saying that there is nothing in this sounder that is excluded by the third specification, as in the case of Rail Road Company *v.* Mellon ; and he makes points as follows :—

First. "The key exhibits the combination patented. It is "not the mere *use* of this combination in a key only that is pat- "ented ; it is the combination itself, and that combination only ; "that is the essential thing and the thing patented, and that "combination is used in the sounder."

Second. As regards the original claim which was disallowed by the patent office, it was understood to be for an "arrangement of a key lever," and refused because a key lever was not the true thing invented ; but they did intend to grant a patent for a certain "combination of parts or elements."

Third. He considers at length the inventor's intent, and expresses his opinion that what is clearly pointed out as invention is a part of the claim whether it precedes or follows the words "I claim."

Fourth. That in the third specification the element of a "circuit-breaking lever" is omitted, and therefore it was intended to extend the claim beyond circuit-breaking levers.

Fifth. That the sounder in a general sense is a transmitter, being the last instrument used in the transmission of the message.

In conclusion he says :—"The defendant's instrument in the "form of a 'telegraph transmitter,' called a sounder, appropri- "ates and embodies the invention clearly intended to be secured "to the inventor under this patent. Looking at all the language "of the application that is designed to set forth the extent "of the inventor's patent, and what he intends to secure by it as "constituting his claim, it is clear that this claim includes the "combination when used in a sounder. So far as respects the "use of this combination, the sounder is the equivalent of the "technical key, for the combination operates precisely alike in "each. All the merits, as it seems to me, are therefore with the "complainant, and the injunction moved for should be allowed.

THE ANGLO CABLE REPORT.

At a meeting of the Anglo-American Cable Company, July 29th, at which Mr. Monck presided, the semi-annual report was read. It states that the receipts for the half year, including £4,096 brought forward, amount to £116,737, showing a decrease as compared with the receipts of the first half of the preceding year, of £22,321. The falling off is attributed to competition, the reduced tariff and the continued depression of trade in Europe and America. The total expenses for the half

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year were £46,818. It is not proposed to declare a dividend for the past quarter, but to carry forward the balance of £2,428, besides £50,000 to be devoted to the renewal fund. The directors say they believe that sooner or later a low tariff will be compulsory; therefore, by taking time by the forelock and making an earnest effort to establish a low tariff they hope to secure the cordial approval and help of the public, without which they cannot succeed. Mr. Monck said the company did not intend to add to the renewal fund after December, unless some unforeseen disaster compelled it to do so. He considered that the Commercial Cable Company had given rebates unfairly, compelling the companies in the pool to lower their rates. The report was adopted, with a few dissenting votes.

The Brooklyn Construction Company have installed a large plant of arc lights for the Municipality of Mobile, Ala., the station being run by two 60-h.p. and one 45-h.p. Westinghouse engines.

The towns of Gastein and Gratz will shortly be lighted by electricity. The town of Temesvar, in Hungary, has already for the last two years enjoyed this mode of illumination for its streets and public buildings.

STATISTICS OF SUBMARINE CABLES.

At a Congress of the Chambers of Commerce of the British Empire, held in London on July 6, a paper was read by Sir James Anderson, on Telegraphic Reform, which was accompanied by the following tabular statement of the present extent and financial condition of the submarine telegraphs of the world.

SUBMARINE CABLE COMPANIES.

Name of company.	Capital. £.	Cable mileage	Reserve including subsidies. £.	Reserve and sinking fund. £.	Dividends on ordinary capital.
Anglo-American.	7,000,000	10,487	291,036	851,872	1¼ per c.
American Telegraph and Cable.	2,800,000	5,537	116,000	†	5 " ‡
Black Sea.	130,000	351	9,047	Nil.	4 "
Brazilian Submarine.	1,450,000	7,496	158,485	45,466	6 "
Commercial Cable.	1,600,000	6,600	225,000	?	?
Telegraphe de Paris a New York.	1,680,000	3,409	64,000*	?	2 per c.
Central & South American.	1,000,000	3,178	80,000*	?	?
Cuban Submarine.	220,000	940	35,161	64,704	8¼ per c.
Direct Spanish.	238,379	1,175	18,780	9,800	Nil.
Direct United States.	1,214,200	2,983	74,221	820,000	3 per c.
Eastern.	5,747,100	19,207	672,358	444,875	6 "
Eastern and South African	9[illegible]0,000	4,554	134,095	109,265	6 "
Eastern Extension.	3,401,900	12,821	506,493	616,945	7 "
German Norwegian	82,240	252	7,156	2,641	5 "
German Union.	330,00	1,119	38,518	58,363	7 "
Great Northern.	1,855,000	5,916	280,094	417,448	8 "
Hamburg Heligoland.	10,500	32	589	260	4 "
London Platino-Brazilian.	483,480	1,058	12,180	9,268	1 "
Mexican.	200,000	620	20,000*	?	?
Montevidean & Brazilian.	101,520	20[illegible]	1,529	500	Nil.
River Plate.	55,500	32	10,000*	?	?
Spanish National.	237,190	2,135	25,000	?	Nil.
Submarine.	338,225	803	131,577	180,465	14¼ per c.
West India & Panama.	1,325,530	4,119	89,020	124,086	Nil.
Western & Brazilian.	1,498,650	2,543	127,396	131,273	2¼ per c.
West Coast of America.	450,000	1,699	45,957	10,000	2½ "
	34,399,414	99,216	3,173,692	3,397,231	

*Accounts not obtainable. Revenue estimated. ‡ No information published.
‡ 5 per cent. guaranteed by Western Union Company.

From the above summary, it appears that the total capital of the cable companies of the world, is in round numbers $167,000,000, and the annual revenue $15,000,000, about nine per cent. gross.

THE WESTERN ELECTRIC COMPANY'S STREET LIGHTING PLANT AT EASTON, PA.

We have recently had the pleasure of visiting the Central Lighting Station at Easton, and of observing the illumination of the streets by the arc system of the Western Electric Company.

The plant is owned and operated by the borough corporation. It was started in operation August 1st. Sixty-five lamps are now in circuit. The installation is very thorough and complete, and the central outfit has been worthily housed by the corporation in a handsome and convenient brick building erected for the purpose.

The excellence of the light service is very apparent to a stroller through Easton streets on a dark night. The number of lights used already exceeds the original contract, and further addition is contemplated at an early day. The steam plant included in the contract of the Western Electric Company, consists of two 70-h.p. tubular steel boilers, and two 60 h.p. Ide engines, furnished by the foundry and machine department of the Harrisburg Car Manufacturing Co.

TELEPHONE STATISTICS IN THE UNITED STATES.

FROM THE AMERICAN BELL TELEPHONE CO.'S EXCHANGE STATISTICS.

	Schedule A. Population over 150,000. Jan. 1, 1885.	Schedule A. Jan. 1, 1886.	Schedule B. Population from 50,000 to 150,000. Jan. 1, 1885.	Schedule B. Jan. 1, 1886.	Schedule C. Population from 10,000 to 50,000. Jan. 1, 1885.	Schedule C. Jan. 1, 1886.	Schedule D. Population of 10,000 and under. Jan. 1, 1885.	Schedule D. Jan. 1, 1886.	TOTAL. Comparative Statement for three years. Jan. 1, 1884.	TOTAL. Jan. 1, 1885.	TOTAL. Jan. 1, 1886.
Number of Exchanges...	16	16	26	25	195	194	585	512	906	772	747
Number of Circuits......	28,909	31,694	15,920	17,437	37,941	40,052	24,670	22,884	97,422	107,440	112,067
Number of Miles of Wire	32,505	41,585	16,018	17,407	32,351	34,459	20,865	20,595	85,896	101,734	114,046
Number of Employés....	1,701	1,817	727	770	1,456	1,547	1,284	1,304	4,762	5,168	5,438
Number of Subscribers..	34,865	38,218	24,631	24,974	47,206	48,461	28,145	26,097	123,625	131,847	137,750

The entire number of offices in the exchange systems, in operation January 1, 1886, was 1,175.

QUICK WORK.

A remarkable feat of tracklaying was performed last week on the New York elevated railroad; perhaps not more remarkable than many others which have not been reported, but worthy of note as showing what can be done with practice and will. Tracklaying on that road is carried on under difficulties, since trains run at 1½ to 5 minutes' intervals at all hours of the day and most of the hours of the night, and at 15 minutes' intervals throughout the few remaining hours.

Contrary to what might be expected, it has been found preferable to do all ordinary track work by daylight, despite the more frequent trains. Probably the very best trackmen on ordinary roads would think they could do nothing whatever in the way of changing rails with passenger trains running five minutes apart, and on a continuous bridge affording only the narrowest and most precarious footing while trains are passing; but this is what was done:

In 95 minutes on the morning of August 18th a gang of eighteen men changed the rails on 1,000 feet of track by taking out 66 old 50-pound rails and putting in as many 70-pound rails in their place, completely spiking them and inserting Bush interlocking bolts at the joints, all without delaying a train.

This was an average of 43 seconds for taking out, and 43 seconds for replacing a rail, including all delays, but 10 rails were taken out and replaced in 3½ minutes, or 10½ seconds for taking out and as much for replacing, and five old rails were taken out, replaced by five new ones and the latter fastened, all in 55 seconds.

This was done on the Third avenue line between Eighteenth and Twenty-third streets, under the supervision of Robert Black, roadmaster, and Louis Gariepy, foreman. With solid ground under foot it would be a remarkable feat. With the dangerous footing which alone was available, it is almost incredible.—*Railroad Gazette.*

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HOW THE CABLE WAR IS REGARDED IN LONDON.

In a circular which it has just issued, the Commercial Cable Company, after quoting from the remarks of the chairmen of the Direct and Anglo-American companies made at the recent meetings of those companies, says: "The last reports of the allied companies point out the great increase of traffic as a result of the adoption of the 6d. tariff. Granted the number of words transmitted by their cables has more than doubled, the receipts have fallen to one-half of what they were last year; thus the situation remains the same as when Lord Monck explained it at the beginning of this year, that is to say, they will have to adopt every possible means to return to a tariff exceeding 1s. 8d. The public should have no hesitation in choosing between the vague promises of the allied companies and the formal affirmation of the Commercial Cable Company. By continuing to support the latter company the public will acquire the certainty of the tariff never being increased to 3s. Our patrons will also understand that their earnest support will induce the Commercial Cable Company to lay a third cable and to still further reduce the tariff of 1s. 8d., which this company has undertaken never to exceed.

A NEW LECTURE LANTERN.

Professor A. Gray and Mr. T. Gray have devised a new electric lantern for lecture purposes. It consists essentially of a small Gramme motor combined with an arc lamp in such a way that the revolution of the motor moves the carbons in opposite directions, and keeps the arc sensibly constant in position. The lamp itself has several advantages, for example, the addition of condenser lenses. The distance of the lenses from the arc can also be changed. The magnification can be readily adjusted to suit the distance and size of the screen, or, on the other hand, a parallel beam may be obtained for spectrum illustration. Moreover, the image of the arc itself can be projected on the screen, to show the mode of wearing of the carbons, the effect of placing impurities in the arc, or the attraction and repulsion of currents and magnets on the arc.—*Engineer and Iron Trades Advertiser* (Glasgow).

PATENT CASE DECISION AFFECTING SIGHT-FEED LUBRICATORS.

In the case of The Detroit Lubricator Co. *v* Frederick Lunkenheimer, the U. S. Circuit Court for the eastern district of Michigan, Henry B. Brown, district judge, has, upon final hearing, made a decree affirming the validity of letters patent No. 196,650, Oct. 30, 1877, to George H. Flower, and awarding profits and damages against the defendant.

The decree is dated June 26, 1886.

The claim of the patent is as follows:

"A lubricator consisting of a condensing-tube, an oil chamber, and a water-tube connected together and operating essentially as described, and for the purposes set forth." This decision would seem to be important to makers and users of lubricators.

INCANDESCENT LAMP MONOPOLY IN ENGLAND.

Pending the appeal of Messrs Woodhouse & Rawson against the decree in favor of the Edison-Swan Co., a meeting is to be convened of all interested in frustrating a monopoly of incandescent electric lighting, with a view of taking concerted action to that end. Messrs Shippey Brothers are moving actively in the matter.

Entomologists in search of extraordinary bugs will do well, with nets in hand, to frequent electric light stations, where the brilliant illumination and open doors and windows attract some rather portentous varieties of nocturnal insects. Gigantic flying beetles and other strange creatures, puzzling to the uninstructed attendants and visitors, court cremation in the brilliant arc lamps.

ELECTRIC LIGHT AND POWER.

Domestic.

The National Electric Light Company has removed its works from Fort Wayne, Ind., to Elgin, Ill. It will have an office in Chicago.

The Ballston Warren P. Freeman Illuminating Company, of Ballston, N. Y., has been incorporated. Capital stock, $25,000. Henry White, Martin Lee, James F. Peckham, Nath. Van Beil and Warren P. Freeman, incorporators.

The Edison Light and Power Company, of Albany, N. Y., has been incorporated. Capital stock, $10,000. W. A. Harcourt, D. Farlin, C. D. Hammond, G. W. Slingerland and E. Danforth incorporators.

The Malden Electric Light Company, of Saco, Me., has been incorporated. Capital stock, $30,000. President, Edward H. Batchelder, Marshfield, Mass.; treasurer, Albert C. Pond, 79-81 Blackstone street, Boston, Mass.

The Electric Light Company, of North Attleboro, Mass., will extend its plant to Attleboro and Attleboro Falls.

The Media Electric Light, Heat, and Power Company, of Media, Pa., has been incorporated. Capital stock, $10,000. Treasurer, Garrett E. Smedley, Morton.

The electric light committee, of Lyons, Iowa, has been authorized to secure bids for lighting the city with electricity.

The Wichita Schuyler Electric Light Company, of Wichita, Kan., has been incorporated. Capital stock, $50,000. J. O. Davidson, and others, incorporators.

The Van Choate Electric Light Company, of New England, of Portland, Me., has been incorporated. Capital stock, $1,500,000. President, George C. Barrett, Boston; treasurer, Frank Q. Brown, Melrose, Mass.

The Waterbury Electric Light Company, of Waterbury, Conn., has been incorporated. Edward S. Hayden, John C. Francis, and L. F. Burpee, incorporators.

The Home Electric Light Company, of Oswego, N. Y., has been incorporated. Capital stock, $50,000. Incorporators, Robert G. Post, Edward P. Penfield, Sidney Van Auken, 152 East 118th street, New York city; Warburton T. Henderson and James Henderson.

The Illuminating Company, of Philadelphia, Pa., has been incorporated. Capital stock, $5,000. Treasurer, Andrew J. De Camp, 20th and Johnson streets.

Westinghouse, Church, Kerr & Co., have recently completed a beautiful incandescent installation for the Ft. William Henry Hotel at Lake George.

The Westinghouse company are now bidding on plants for electric lights for about ten cities of different sizes in both the east and west. These range from 2,000 to 10,000 lamps in each town, and the company will, in case they get the contracts, furnish everything necessary for successful operation.

The subject for the next international competition for the prize offered by the king of the Belgians, is the "Progress of Electricity Applied to Motive Power and Illumination." The essay must be written in French.

It has been reported that dwellers in Elizabeth, N. J., have this summer observed, to their great comfort, a marked decrease in the annual plague of mosquitos. The cause seems to have been discovered, and it is commended to the attention of other like places. A citizen, on his way to the train for New York one morning recently, noted a trimmer of electric lamps pouring out a quart of dead mosquitos from a lamp globe.

The Westinghouse Electric Co. are fitting up a mammoth test room at their Pittsburg manufactory. A 200 h. p. Westinghouse engine will be used for testing dynamos alone, besides a 75 h. p. in the shops, and 75 h. p. operating a three mile circuit on their high tension incandescent system.

The Wainwright Manufacturing Company, 65 and 67 Oliver street, Boston, Mass., and 98 Liberty street, New York, manufacturers of feed-water heaters, filters, expansion joints, radiators and corrugated tubing, have been forced by their numerous orders to enlarge their plant, and are erecting an addition to their factory of four stories, 31x78 feet, which will contain machine shop and currugating and radiator departments. Their former building has been moved, and will also be utilized as a machine shop. By this change they will be enabled to increase their product three or four times, and permit them to fill their accumulated orders.

There are 1,600 electric lights in use in the city of New Orleans, all connected with one station.

The city of Orange, N. J., has contracted with Mr. R. T. McDonald, of the Fort Wayne Jenney Company, for a plant of 75 lights to be used in lighting the city.

The Electric Underground Conduit Company, of Portland, Me., has been organized with the following officers: President, George F. Milliken; treasurer, Frank J. Milliken; directors, George F. Milliken, George H. E. Trouvelot, Warren D. B. Smith, Frank J. Milliken. Capital stock, $300,000; paid in $45.

The Baltimore and Ohio Telegraph Company have introduced a system of commutation books for the convenience of their patrons. The books contain stamps of various denominations similar to postage stamps. These stamps affixed to a message are received at the telegraph office in payment as money would be, and are sold, bound up in books, at a discount. Eleven dollars and four cents worth of commutation stamps are sold for ten dollars.

A report on M. Marcel Deprez's experiments on the transmission of force by means of electricity has been at last prepared.

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It appears from it that with one generator and one receptor, it is possible to transport to a distance of about thirty-five miles a force, capable of being used for industrial purposes, of 52-h.p. with an efficiency of 45 per cent., without exceeding a current of 10 ampères. The maximum electromotive force is 6,290 volts. The report states that this high tension does not give rise to any danger, and that no accident has occured during the past six months. The commission is of the opinion that the transmitting wire may be left uncovered on poles provided it be placed beyond the reach of the hand.

The American Acoustic Company, Portland, Maine. Capital stock, $600,000. President, Jeremiah Prescott, Arlington. Mass.

The U. S. Electrical Construction Company, Dubuque, Iowa. Capital stock, $50,000. Secretary, Edward T. Kein.

Foreign.

A proposal had been made for electrically lighting the promenade at Brighton, but at a recent meeting of the town council it was decided not to take any action in the matter at present.

We understand that the admiralty have just placed an order with the Woodhouse and Rawson Electric Manufacturing Company for over 7,000 switches, besides fusible plugs, brackets, and other articles.

The employes from Sheerness, who have been undergoing a complete course of training in the electric shop in Portsmouth dockyard, will shortly return to their own yard, in order to constitute the permanent electrical staff, which was ordered by the admiralty to be established some time since. They will be intrusted with the work of fitting the "Mohawk," torpedo cruiser, with all the necessary torpedo appliances.

The "Volta," a new electric launch, has made a first and successful trip on the Thames; the distance accomplished was forty-six miles, with electric power still in hand. Her dimensions are 37ft long by 7ft. wide, and she is driven by a Reckenzaun duplex motor and gear, constructed by Messrs. Stephens, Smith & Co., the electrical energy being obtained from a set of 61 E. P. S. accumulators. The speed is varied by a novel switch arrangement.

Dr. S. T. Stein, of Frankfort-on-Main, considers that the best battery for medical purposes would be one in which the exciting liquid does not evaporate, so that no salts are formed on the upper edge of the jar; he, therefore, adds gelatine to manganese batteries. The combination adopted by him being a mixture of gelatine, glycerine, sal-ammoniac and salicylic acid, the electrodes consisting of a carbon cylinder, with bioxide of manganese for the positive pole and a zinc pencil for the negative pole. The internal resistance of this primary battery is stated to be about .5 ohm. and its E. M. F. 1.085 volt.

The gas company of Montreal, Canada, refuses to make way for the electric light. The main thoroughfares are now illuminated by both arc lamps and gas; but the municipality refuses to pay for the latter, which was ordered to be discontinued some time since. The gas company has, therefore, commenced a lawsuit against the corporation.

PERSONAL MENTION.

Mr. H. C. Townsend, sometime a practitioner in this city, and Mr. Frank Mac Arthur, late law clerk and Examiner of Interferences, U. S. Patent Office, have formed a partnership as attorneys-at-law, and have taken an office at 5 Beekman street (Temple Court), New York city. They confine their legal practice to patent law exclusively, and announce that they will solicit U. S. and foreign patents These able and experienced gentlemen will make a valuable addition to the ranks of patent law practitioners in New York.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICIAN AND ELECTRICAL ENGINEER, *by* Pope & Edgecomb, *Solicitors of Patents for Electrical Inventions*, 11 *Wall Street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From June 22d to August 10th, 1886 (inclusive).

Alarms and Signals:—*Water Level Indicator*, W. S. Mayers, 344,121, June 22. *Electric Alarm*, C. M. Barnes, 344,233. *Electric Burglar Alarm*, S. T. Dickens, 344,358, June 29. *Signal Box for Fire Telegraph and other Circuits*, J. C. Wilson, 344.430. *Municipal Signal Apparatus*, J. C. Wilson, 344,467. *Electric Bell*, E. Carhart, 344,940, July 6. *Fire Alarm Signal Box*, S. A. Chase, 345,572, July 13. *Electrical Call*, E. A. Reeder, 346,314, July 27. *District Telegraph*, J. W. Chase, 346,355. *Electric Alarm*, C. Crockett and C. C. Allen, 346,532, August 3. W. L. Glanville, 346,587. *Electrical Annunciator*, D. Rousseau, 346,609. *Door for Signal Boxes and Similar Apparatus*, B. S. Flanders, 346,847. *Electric Annunciator Target*, M. Ullman, 346,876. *Electrical Signaling Apparatus*, T. A. Edison, 347,097, August 10.

Clocks:—*Chronometer Electric Call*, W. L. Bailie and G. H. Mills, 344,072, June 22. *Electric Clock*, R. E. Fenner, 345,292, July 13. *Electric-Clock Movement*, S. C. Dickenson, 346,094, July 27. *Circuit-Closer for Primary Electric Clocks*, A. Ramel and W. W. Dean, 346,863, August 3. *Clock-Synchronizing Device*, same, 346,862. *Electrical Device for Synchronizing Clock Pendulums*, H. Whiting, 346,970, August 10.

Conductors, Insulators, Supports and Systems:—*Underground Conduit*, J. F. Munsie, 344,324, June 22; H. Fondersmith, 344,732, June 29; J. Grant, 344,827, July 6; R. Macdonald, 344,843; F. Wheaton, 346,250, July 27; W. L. Robinson, 346,688, August 3; E. Campbell, 346,840. *Suspended Electric Conductor*, C. J. Van Depoele, 344,425, June 29. *Housing for Electrical Conductors*, A. T. Woodward, 344,764. *System of Distribution*, H. M. Byllesby, 345,212, July 6. *System of Telephonic Communication*, C. A. Bell, 346,708, August 3. *Machine for Covering Insulated Wires with Lead*, A. K. Eaton, 345,956, July 20. *Machine for Winding Lead Tape upon Cables*, W. R. Patterson, 346,414, July 27. F. P. Duplain, 346,433. *Insulating Composition*, J. Fottrell, 344,823, July 6. *Machine for Making and Trimming Compound Wire Cables*, G. M. Cruikshank, 346,645, August 3. *Insulator-Block for Electric Conductors*, T. Hawken, 346,475. *Electric Circuit*, H. C. Spaulding, 346,510, *Splice for Underground Cables*, W. R. Patterson, 346,942, August 10. *Telegraph Insulator*, John Wilson, 346,971 and 346,972. *Electrical Conductor*, J. R. Finney, 346,990. *Electric Subway*, R. L. Harris, 344,962, July 6.

Dynamo Machines and Motors:—*Dynamos*, C. A. Parsons, 344,542, June 29. W. E. Freeman, 344,801. *Commutator-Brush*, E. Thomson, 345,336, July 13. *Motors*, J. E. Emley, 344,262, June 22. C. Doriot, 344,643, June 29, E. F. Recordon, 344,679. E. Thomson, 345,334, July 13. A. L. Parcelle, 345,720, July 20. J. Beattie, Jr., 346,[illegible]27, August 3. *Apparatus for Transmitting Power from Electric Motors*, C. P. Elieson, 344,260, June 22. *Armature for Dynamos*, E. P. Warner, 346,965, August 10. *Regulator for Dynamos*, S. H. Short, 347,204.

Electrolysis:—*Process of Electro-depositing Nickel*, E. C. Bates, 346,258, July 27.

Galvanic Batteries:—W. L. Gates, 344.528, June 29. G. F. DeSolome, 344,946, July 6. C. Wirt, 345,756, July 20. T. Erhard, 346,032. O. Lugo, 346,053. W. W. LeGrand, 346,207, July 27. H. J. Brewer, 346,395. J. Beattie, Jr., 346,528, August 3. *Zinc for Battery*, W. S. Platt, 344,750, June 29. *Connection for Battery*, G. F. DeSolome, 344,947, July 6. *Carbons for Battery*-E. Berliner, 347,023, August 10. *Art of Regenerating Exhausted Galvanic Cells*, W E. Case, 344,346, June 29.

Ignition:—*Gas Lighting Device*, C. H. Crockett and C. C. Allen, 346,533, August 3. *Fuse for Blasting*, J. P. A. Scola, 347,013, August 10.

Lamps and Appurtenances:—*Arc Lamps*, N. McCarthy, 344,188, June 22. J. R. Dales and W. H. Markland, 344,252. O. Romanze, re-issue, 10,738. C. Doriot, 344,642, June 29. W. E. Freeman, 344,802. A. G. Waterhouse, 345,937, July 20. E. B. Cutten, 346,430, July 27. *Arc Lamp for Locomotive Head Lights*, G. C. Pyle, 346,561, August 3. *Clutch for Electric Lamps*, C. B. Noble, 346,217, July 27. *Incandescent Lamps*, C. E. Buell, 344,843, June 29, and 345,008, July 6. *Electric Illumination*, same, 344,344, June 29. *Holder for Incandescent Lamps*, E Thomson and E. W. Rice, Jr., 344,692. *Socket for Incandescent Lamps*, E. Thomson, 345,335, July 13 *Circuit Controlling Key for Incandescent Lamps*, A. G. Brown, 345,880, and 346,020, July 20. *Electric Light Reflectors*, W. A. Jones, 344,582, June 29. *Electric Lamp Support*, G. J. Hammerstein, 344,652. *Machine for Making Carbons for Electric Lamps*, A. Pfannkuche, 345,539, July 13. *Apparatus for Carbonizing Fibre*, A. L. Reinmann, 345,860, July 20. *Process of Making Incandescents*, C. M. Balls, 346,345, July 27. A. de Lodyguine, 347,164, August 10. *Making Carbons*, J. T. Lister, 347,247.

Measurement:—*Electrical Meter*, W. L. Stevens, 346,957, August 10.

Metallurgy:—*Electro-Magnetic Apparatus for Separating Ores*, H. P. J. Kessler, 345,883, July 13.

Miscellaneous:—*Coupling for Lightning Rods*, F. A. Foy, 344,096, June 22. *Induction Coil*, F. W. Jones, 344,318. *Apparatus for Converting Heat Energy into Electrical Energy*, W. E. Case, 344,345 and 344,347, June 29. *Connecting Clip for Electrical Apparatus*, M. M. M. Slattery, 344,417. *Automatic Means for Opening and Closing Electric Circuits*, G. P. DeSolome, 344,948, July 6. *Contact Finger for Vibrating Reeds*, R. G. Brown, 345,209. *Electric Chain Battery*, R. N. Rockwell, 345,178. *Regulator for Electric Circuits*, J. M. Wightman, 345,561. *Electrical Synchronous Movement*, A. L. Parcelle, 345,721, July 20. *Electrical Indicator*, C. Wirt, 345,755. *Apparatus for Demagnetizing Watches*, C. K. Giles and R. E. Fenner, 345,838. *Electrical Switch*, E. G. Waters and R. G. Sweeney, 346,183, July 27. *Galvanic Belt*, J. H. Murray, 346,215. *Electrical Connection and Guard Therefor*, G. D. Burton, 346,423. *Electric Circuit*, H. C. Spaulding, 346,509, August 3. *Electrical Switch*, R. G. Sweeney, 346,515. *Hydraulic Lead Press*, J. Robertson, 346,563. *Electroplated Fabric*, R. F. Neuninger, 344,397, June 29. *Valve for Mercurial Pumps*, A. L. & C. F. Reinmann, 345,543, July 13. *Key Board Attachment for Musical Instruments*, R. T. Smith, 346,237, July 27. *Advertising Device*, J. W. Knell, 346,924, August 10. *Heat Regulator for Incubators*, G. A. Muenchinger, 346,988. *Multiple Series Cut Out*, C. F. Brush, 347,025. *Locking and Releasing Mechanism for Locks*, W. C. Fisher, 347,029. *Automatic Electric Barrel Register*, G. W. Hey, 347,038. *Electro Magnetic Locks*, F. Sedgwick, 347,068, 347,069, 347,070 and 347,071. *Electric Welding*, E. Thomson, 347,140, 347,141 and 347,142.

Railways and Appliances:—*Railway Signal*, B. H. Gedge, 344,099, June 22. *Signal for Switches*, same, 344,100. *Train Brake*, H. Hinckley, 344,736, June 29. *Railway Signal*, M. W. Long, 345,641 and 345,642, July 13. *Electric Railway*, J. C. Henry, 345,845, July 20. T. P. Chandler, Jr., 346,465, August 3. *System of Lighting Railway Trains by Electricity*, W. A. Stern, 346,388, July 27. *Railway Signal*, H. Liemke, 346,484, and 346,485, August 3. *Pneumatic and Electric Railway*, E. F. Edgar, 346,902, August 10. *Railway Signal*, J. H. Reinhardt, 346,946. *Automatic Suspended Switching Device for Electric Railways*, C. J. Van Depoele, 346,963. *Electro Magnetic Car Brake*, I. A. Timmis and G. Forbes, 347,075.

Secondary Batteries:—S. Farbaky and S. Schenex, 344,957, July 6. A. L. DeVirloy, E. Commelinz, and G. Bailhache, 345,124. A. DeKhotinsky, 347,231, August 10. E. T. Starr, 347,258 and 347,259. E. Julien, 347,300. *Composition for Electrodes for Secondary Batteries*, S. L. Trippe, 344,882, July 6. *Construction of Electrode for Secondary Batteries*, A. Khotinsky, 345,511, July 13.

Telegraphs:—*Key and Register*, L. S. Crandall, 344,351, June 29. *Telegraph Instrument*, G. W. Stewart, 344,505. *Siphon Recorder*, C. Cuttriss, 344,778. *Printing Telegraph Receiver*, H. Mahnken, 345,245, July 6. *Key*, R. A. Macready, 346,930, August 10.

Telephone Systems and Apparatus:—*Telephone*, W. C. Turnbull, 344,067, June 22. J. J. Barrier and F. T. Lavernede, 344,153. S. Bergman, 344,988. July 6. A. M. Phelps, 344,983. J. Emner, Jr., 346,031, July 20. W. C. Lockwood, 346,377, July 27. *Transmitter*, E. Berliner, 344,514, June 29. J. P. Young, 345,658, July 13. G. Brambel, 345,762, July 20. H. Ehrlich, 346,846, August 3. *Receiver*, W. C. Turnbull, 344,333, June 22. Same, 346,962, August 10. *Induction Coil*, D. Drawbaugh, 344,818, July 6. *Micro Audiphone*, F. M. Blodgett, 345,025. *Method of Transmitting and Receiving Articulate Sounds to Distant Points*, E. S. Spaulding, 345,084, and 345,085. *Telephone Exchange Switch*, C. E. Scribner, 345,325, July 13. *Test Plug for Multiple Switch Boards*, same, 345,326. *Acoustic Telephone*, G. W. Lord, 346,594, August 3. *Automatic Telephone Toll System*, P. L. Rose and G. Rein, 346,865 and 346,866, August 3.

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THE ELECTRICIAN AND ELECTRICAL ENGINEER.

Conducted by F. L. POPE. G. M. PHELPS, JR., R. W. POPE, } Associate Editors.

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NEW YORK, OCTOBER, 1886.

DETROIT MEETING OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION.

WHILE to many the semi-annual meetings of this association may seem too frequent, the decided changes in the character of the discussions seem to indicate that six months' experience is ample to bring out new ideas and develop new methods in the practice of a comparatively young industry. The relative merits of large and small, or low and high speed engines, which have occupied so much attention at previous meetings, have been so thoroughly discussed that little testimony which is actually new can now be presented; consequently, most of the time hitherto devoted to this topic was wisely devoted to other subjects. Among these none awakened so much apparent interest as that of the electrical transmission of power. So far as we learn nearly all of the various electric light companies have experimented more or less with small motors. This is no doubt because of a more immediate and obvious demand for light power which can thus be distributed to otherwise inaccessible places. Again the energy required for work of this character is not so excessive but that it may be more readily spared without apparent detriment to the lighting business. Progress already made, however, is sufficient to prove that this is a very important industrial field, and one which will extend with great rapidity as soon as it is known that light power may be obtained in this manner. At present it is difficult to obtain any accurate information regarding what is being done even by those who are well posted in electrical affairs, so that it may be assumed that people who are to become the patrons of a successful motor business have not yet had the subject properly presented to them. Again, many of the advocates of existing systems of power transmission are bitterly opposed to what they consider an interloper in the field of mechanics, and will in many cases successfully oppose, for a time at least, any radical departure from old devices. The successful distribution of power for light machinery will lead up to heavier work, and electric railways are not to be ignored as substantial sources of revenue. If it be correct as stated, that the line in operation at Windsor, Ontario, is yielding a profit of $500 per month on a capital of $9,000, the investment must be considered very satisfactory, and it is morally certain that there are in this country hundreds of much more promising locations than that for the establishment of similar enterprises.

The incandescent lighting business is evidently gaining in favor with those who have hitherto devoted their attention solely to arc lighting. The successful operation of large power incandescent lamps, and their superiority for in-door lighting is leading to their more general introduction, the principal difficulty being that it is not always possible to get enough of them. With the increase of facilities, however, and improved methods of manufacture all this will be changed, and it may not be long before we hear a complaint of over-production. This leads to the observation that rather curiously no statements were made regarding the use of the so-called 1,200 c. p. arc lamps, which have been rapidly coming into favor for some time. It is generally admitted that for ordinary purposes they give equal, and in many instances better satisfaction than those of larger power, while they can be produced at a less cost, and this is the very line of discussion which is usually most acceptable to the practical men who attend these meetings.

In advocating the claims of Detroit as a suitable place for holding the August meeting, the inspection of the tower-lighting system proved a most successful argument in favor of that city. We have never experienced so general a change in opinion, caused by actual observation, as there was upon this subject. A large number of the visitors were strongly prejudiced against the tower system, but after thorough examination, became its earnest supporters. They endeavored to eliminate entirely from their minds the possibly exaggerated effect produced by the eleven pairs of white horses which were attached to the same number of coaches for the tour of investigation, and render a verdict in accordance with the evidence.

Altogether the Detroit meeting was entirely satisfactory, and those who attended will not soon forget their very pleasant and instructive experience.

SUBWAY PROGRESS IN NEW YORK.

THE subway question continues to be the most vital topic of interest in electrical circles in this city.

Work was begun just a month ago, from Twenty-third street northward, according to date assigned, as noticed in our last issue. About ten blocks have been completed, and the work is now progressing slowly, owing, it is said, to the inability of the Dorsett factory to supply the conduits fast enough.

There seem to be several embarrassing features in the present situation of the matter. Perhaps they are naturally due to an attempt to accomplish in a wholesale and summary manner, an undertaking that seems still to require tentative work, and much careful consideration of

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difficulties not fully solved to the satisfaction of a majority of the various electrical interests, which are the parties most directly and immediately concerned, or of the public.

The community is not yet informed with any certainty as to the organization and resources of the company that has contracted to construct and manage the subways. It is alleged, in the daily press, that the company is substantially without resources, and that the work so far is being done on credit by the trench contractor and the Dorsett factory. It is not surprising that capitalists should hesitate to put money into an enterprise accompanied by so many elements of uncertainty and doubt, involving practical, administrative and legal questions. It is far from certain that the plan adopted by the commission is the best now attainable for a comprehensive system, providing in a permanent manner for all classes of electric conductors; how the administration of the business is to be conducted, when the subways shall be completed, is not announced with sufficient clearness to satisfy the electric companies; and the rights and powers of the commission and of the Consolidated Subway Co., are attacked and threatened in the courts.

The Western Union Telegraph Co. announces its purpose to contest the right of the commission to compel it to use the conduits; and has begun to run cables on the elevated railroad structure. It also proposes to test its rights by an application for a mandamus to compel the Public Works department to grant permission for an extension of the company's underground line in West street from Cortlandt street to Pier 16. Another important case may speedily be brought before the courts, probably by means of an injunction to prevent any interference with the wires of the company lately stretched along the elevated railroad in Third avenue. On this point Dr. Green refers to section 8 of article I. of the Constitution of the United States, which gives power to congress "to establish post-offices and post-roads," and "to regulate commerce with foreign nations and among the several states." He then cites the decision of the United States Supreme Court in the Pensacola Telegraph case, thus summarized by Chief-Justice Waite in the decision of a similar case arising in Texas:

> In Pensacola Telegraph Company *vs.* Western Union Telegraph Company (96 U. S., 1), this court held that the telegraph was an instrument of commerce, and that telegraph companies were subject to the regulating power of congress in respect to their foreign and inter-state business. A telegraph company occupies the same relation to commerce, as a carrier of messages, that a railroad company does as a carrier of goods. Both companies are instruments of commerce, and their business is commerce itself. They do their transportation in different ways, and their liabilities are in some respects different, but they are both indispensable to those engaged to any considerable extent in commercial pursuits.

President Green explains that the legislature of Florida had granted the Pensacola Telegraph Co. exclusive control of the telegraph lines in that state, just as the New York legislature had given the electrical subway commission exclusive power to regulate telegraph wires in this city. The Western Union company, however, made a contract with the Pensacola Railroad Co. to run its wires along the latter's route. An injunction was obtained against the Western Union company by the Pensacola Telegraph Co., and was sustained by the state court. On appeal to the Supreme Court of the United States, however, it was held that although the state retained the right of eminent domain in regard to the site for telegraph lines, the contract of the Western Union company with the Pensacola Railroad Co. could not be abrogated by the state law. The case of the elevated railroad is a similar one, and comes under the power of congress to regulate inter-state commerce. The elevated railroad is a post-road, on which the United States mails were carried every hour of the day, and every telegraph wire which has been laid along it is an inter-state wire.

The purpose of the Western Union company to avail itself of every legitimate means to avoid placing its conductors in the control of another corporation seems not unreasonable. There is no good occasion for raising an outcry, as is done by some of the daily press, because it proposes to contest in court the legality of the subway commission or its powers. The stringing of its conductors in cables upon the elevated railroad structures is as effectual a removal of them from the streets, so far as the public is concerned, as burying them in the ground; and there would seem to be much to be said in favor of the plan as a permanent disposition of a large part of the Western Union wires.

Mr. Roswell P. Flower, president of the subway commission, in reply to a question as to the probable action of the commission in the matter, is reported as saying, "As I understand it, no one yet knows the company's purpose in placing its wires on the elevated road. It may only be a makeshift, as they cannot put up any more poles, or it may be a separate arrangement for through wires. Until our subway is ready to receive their wires we neither can nor shall take any legal action against the company. The law, however, is perfectly clear, and authorizes us, on the completion of the subway, to force all electric companies to lay their wires in the subway conduits. If any company refuses to comply with this law we shall legally force them to comply. And so with the Western Union. I suppose at present they can lay their wires where they please, providing the property owners, whose rights they infringe, do not object. But every wire of the Western Union company will have to go into the subway when it is finished."

The subway commission would be in better position to attack the legality of the Western Union company's transfer of wires to the railroad structure if the underground conduits were finished, ready to receive all electric conductors. The commission seems to be in a bellicose temper, and will, probably, in due time, make a fight to get the Western Union wires into the conduits. If the public take an inimical view of the course of the Western Union company in this matter, it seems to us it will be due rather to that company's well earned renown for high-handed proceedings than to any intrinsic "cussedness" in their proceedings in the premises.

The slowness of the present production of the sections of conduit creates an embarrassment in the progress of the work. It does not keep pace with the rate of work easily attained in preparing the trench and laying concrete and brick; and may cause a failure to finish in time the lengths of subway proposed to be completed before winter. It is

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reported that the Consolidated Subway Co. is casting about for other sources of supply, and that they may make use of some different form of conduit in part of the work. By their contract with the commission the second section of subway on Sixth avenue, from Twenty-third street south to Carmine street, must be commenced at once. Makers of competing conduits are availing themselves of the situation to invite further examination and test of their plans; while the New York Electric Lines Co. is still pressing on in its efforts to obtain a permit to open streets to lay conduits on its own account. Along with many other annoyances, the commission is troubled about its permit to open streets for its work. It seems to have been issued by ex-commissioner Squire one day after his dismissal from office, and is apparently invalid. Altogether a subway commissioner's lot, just now, "is not a happy one."

In the hearing of preliminary questions in the government suit against the American Bell Telephone Co., begun September 20th, at Cincinnati, by Circuit Judge Jackson and District Judge Sage, and of which we have reports including the 24th, the contention thus far has been upon the question of jurisdiction. The jurisdiction of the court was attacked by the counsel of the defendants through a motion to quash the marshal's service on two grounds, viz., that the return of the marshal was untrue and that it was insufficient in law. The service of the marshal was upon alleged agents and partners of the defendant company, found in various cities of Ohio. The complainant filed a motion to strike from the files the defendants' motion to quash the service. The court overruled the complainant's motion to strike out defendants' motion, except that part which raised the question of the legal sufficiency of the return, allowing defendants to stand on their plea in raising the question of the verity of the return. Five days were occupied in argument on this issue, at the end of which the court announced that it desired to hear fully from counsel, and would examine any briefs that might be handed up.

The preliminary question of jurisdiction in this case seems to be one of much significance, and to involve points not clearly established in respect to service upon patent-holding corporations.

It goes without saying, that this extraordinary suit will constitute a "celebrated case" in the annals of patent litigation, notable in the manner of its inception, as well as in the importance of its subject-matter, and the magnitude of the interests involved. The appearance of popular prejudice and excitement over the question, so assiduously cultivated by the daily press a year ago, seems to have subsided altogether.

An amateur photographer, with leisure on his hands for strolling, and having a portable instantaneous camera, might derive much amusement for himself, and do the public some service, by getting together a few portraits of District Messengers, taken unawares on their travels. A few such photographs, judiciously captured, and presented to the managers of the district companies with the request that they be set up to public view alongside the pictures of the blue clothed and brass buttoned Mercury painted on their office signs, might possibly lead to some improvement in the present tardy service. They would certainly add to the enjoyment of leisurely pedestrians with a taste for sign boards. A manager with any sense of humor would certainly do *something* about it and any change would be acceptable. As a sample of similar observations, we may mention that we were greatly amused some days ago by the evident enjoyment and complacency of a messenger boy, in a down-town street, astride a railing, and practicing for entrance to a drum corps, probably, with two sticks that obviously belonged to the bundle at his side for delivery.

The Western Union Telegraph Co. has again passed a quarterly dividend. The price of its shares has recently been remarkably strong, notwithstanding the lack of dividends, and the unfavorable outlook for telegraph earnings of this and other companies. In the president's quarterly report Dr. Green deplores "the great amount of business being done between the large commercial centres without profit, if not at absolute loss." The full returns for the quarter ending June 30, show earnings less by $96,120, than the estimate submitted at the last previous meeting.

In the statement of Sept. 8th, it is stated that, "the net revenues of the quarter ending Sept. 30, based upon nearly complete returns for July, partial returns for August, and estimates of the business for September, will be about $1,200,000."

It is rare to find among people well acquainted with electrical phenomena, theoretically or practically, any one rash enough, in the present state of knowledge, to hazard a definition, stating just what electricity is. Now and then such an attempt turns up. Here is the latest we have seen. "Electricity is the energy of molecular vibration caused by any disturbance of the normal attraction or condition of matter." This luminous definition appears in the scientific notes of an electrical journal of recent date; as a contribution, it is proper to say.

It seems at first rather odd that so simple a matter as "wire joints" should require to be treated as a prominent subject at a convention such as that of the Electric Light Association; but the racy and instructive paper of Mr. C. C. Haskins on that topic (printed on page 377) made it very clear that so elementary a feature as the joining of two conductors, safely and efficiently, had been much neglected in practice, and that such neglect had caused much loss and waste.

We have to regret an inadvertance in our September issue, in failing to name Professor Rowland as the author of the vigorous and suggestive address on "The Physical Laboratory in Modern Education," which we reprinted merely as an "Address Delivered at the Tenth Anniversary of the Johns Hopkins University," without naming the author.

The recent earthquake afforded an excellent opportunity for the "cranks" who are always heard from through the daily press after any notable public disturbance, offering theories, explanations and warnings of varying degrees of absurdity. Electricity is accused of producing the earthquake, by a correspondent of a prominent daily paper.

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ARTICLES.

THE HEATING OF AERIAL CONDUCTORS BY ELECTRIC CURRENTS.

BY J. GILBERT WHITE, PH.D.

(Continued from page 292.)

TABLE XXIV.

Changeable Wire. No.	Changeable Wire. Diam. in mils.	Resist. of changeable wire.	Resist. of both.	Resist. of No. 20.	Thompson Ammeter. Position of movable coils.	Thompson Ammeter. Reading.	Current in ampères.	% increase in resist. of changeable wire.	% increase in resistance of No. 20 wire.	Rise in temp. in degrees C. of changeable wire.	Rise in temp. in degrees C. of No. 20 wire.	Relative rise in temp. of the 2 wires, No. 20 taken as 100.
20	30.8											
12	78.9	1023	7395	6372	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	78.9	1064	10305	9241	8	29.5	17.03	4.01	45.08	10.33	116.1	8.89
16	49.1	2227	7540	5313	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	49.1	2412	9131	6719	8	20.7	13.61	8.31	25.57	21.4	65.90	32.47
18	39.8	3254	8605	5351	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	39.8	3771	10788	7017	8	21.56	14.18	15.88	31.13	40.93	80.23	51.01
24	19.4	5424	7554	2130	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	19.4	6715	8995	2280	32	43.54	7.16	23.80	7.04	61.34	18.14	338.15
28	11.96	6626	7697	1071	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	11.96	7857	8950	1093	32	23.34	3.84	18.58	2.05	47.89	5.29	905.3

TABLE XXV.

d — diam. of bare wire in mils.	d — diam. of insulation in mils	R, resist. of insul. part wire.	R' — resist. of both parts wire.	Resist. bare part of wire.	% increase resist. of insul.	% increase resist. of bare.	Rise in temp. of insul.	Rise in temp. of bare.	Thompson Ammeter.	Current in Ampères.
"UNDERWRITERS'" WIRE. Nos. 16 and 18.										
49.8	116.0	3498	6963	3465	0.0	0.0	0.0	0.0	0.0	0.0
49.8	116.0	3833	7820	3987	9.58	15.07	24.7	38.8	27.37	18.0
39.5	107.0	3885	7490	3605	0.0	0.0	0.0	0.0	0.0	0.0
39.5	107.0	4272	8469	4197	9.96	16.42	25.6	42.3	22.22	14.61
SILK-COVERED WIRE, SINGLE "WRAP."										
48.9	51.1	2909	5650	2741	0.0	0.0	0.0	0.0	0.0	0.0
48.9	51.1	4007	8081	4024	37.39	46.76	95.5	120.0	22.66	29.80
CLARK INSULATED WIRE CO.'S WIRE.										
38.2	207.0	3738	7099	3361	0.0	0.0	0.0	0.0	0.0	0.0
38.2	207.0	4171	8446	4275	11.58	27.17	29.4	69.3	13.70	18.02
38.8	235.0	4150	8020	3870	0.0	0.0	0.0	0.0	0.0	0.0
38.8	235.0	4760	10075	5315	14.83	37.34	36.9	96.2	15.90	20.91
49.6	235.0	3920	7512	3592	0.0	0.0	0.0	0.0	0.0	0.0
49.6	235.0	5143	9198	4055	11.27	31.20	28.9	80.0	19.30	25.38
63.5	301.5	3183	6388	3205	0.0	0.0	0.0	0.0	0.0	0.0
63.5	301.5	3669	8272	4603	17.11	48.62	44.33	112.4	31.02	40.79
OFFICE WIRE. Nos. 12, 16, 18 and 20.										
78.9	187.0	3717	7320	3603	0.0	0.0	0.0	0.0	0.0	0.0
78.9	137.0	4119	8317	4198	10.82	16.51	27.9	42.6	27.33	39.54
49.1	106.0	3614	6930	3316	0.0	0.0	0.0	0.0	0.0	0.0
49.1	106.0	4146	8222	4076	14.72	22.92	37.94	59.07	32.95	21.76
39.8	98.0	2657	5238	2581	0.0	0.0	0.0	0.0	0.0	0.0
39.8	98.0	2936	6016	3080	10.42	19.38	26.85	49.82	45.82	15.07
30.8	90.0	2607	5293	2686	0.0	0.0	0.0	0.0	0.0	0.0
30.8	90.0	2820	5903	3083	8.17	14.78	21.06	38.09	30.59	10.06

Throughout the remainder of this article the following symbols are used with the signification attached:

C — current in ampères.
R — resist. of conductor in ohms.
R' — resist. of conductor at temp. $T_1 = R(1 + \varphi T)$.
φ — change in resist. of copper for rise of one degree centigrade = .00388.
T — excess of temp. of conductor over that of room in degrees centigrade.
T_1 = excess of temp. of outside of bare wire or of insulation over temp. of room.
H — rate in calories per second at which heat is developed in conductor $= \frac{C^2 R}{9.81 \times .424}$
J — Joule's equivalent = 4.159 watts = 1 calorie.
r_B — radius of bare wire.
r_I — radius of outside of insulation.
d_B and d_I — corresponding diameters.
t — time in seconds.
K — thermal conductivity of insulation.
a — specific electrical resist. of conductor in ohms = 1.652×10^{-6}.
E — absolute emissive power of bare wire or heat given off from one square centimetre of surface, in calories per second, when the wire has an excess of temp. of one degree centigrade over that of surrounding air.
E_I — absolute emissive power of insulation.

Continuing now our theoretical discussion, let us take up first the problem of how the temperature, T, of a bare wire varies with the time after starting a constant current through it. We can readily see that at the first instant the heat developed all goes to warm up the conductor, but as soon as the wire is at all warmed emission of heat begins.

As H represents the heat developed per second, we may represent the rate at which heat is stored in the conductor by S, and the rate at which it is lost or given off by L. Then for any small time we may write

$$H\,dt = L\,dt + S\,dt \qquad (1)$$

Now if we let q = quantity of heat necessary to raise the temperature of conductor one degree, then, since T = the excess of temp. of conductor over that of room, $\frac{S\,dt}{q} = dT$ = rise in temperature of conductor during dt.

We may, therefore, substitute $q\,dT$ for $S\,dt$ in the above equation, giving

$$H\,dt = L\,dt + q\,dT \qquad (2)$$

$$q\,dT = (H - L)\,dt \qquad (3)$$

$$\text{Now } H = \frac{C^2 R'}{J} = \frac{C^2 R}{J}(1 + \varphi T);$$

and by Newton's law, L = surface of conductor $\times T \times E$ or $L = 2\pi r l T E$. Substituting these values in (3) we have

$$q\,dT = \left(\frac{C^2 R}{J}(1 \times \varphi T) - (2\pi r l E T)\right) dt \qquad (4)$$

$$dt = \frac{q\,dT}{\frac{C^2 R}{J}(1 + \varphi T) - 2\pi r l E T} \qquad (5)$$

Representing $\frac{C^2 R}{J}$ by H again, and $2\pi r l E$ by E' we have

$$dt = \frac{q\,dT}{H + H\varphi T - E'T} \qquad (6)$$

$$dt = \frac{q\,dT}{H - (E' - H\varphi)\,T} \qquad (7)$$

$$\int_{-o}^{t} dt = \int_{-o}^{-T} \frac{q\,dT}{H - (E' - H\varphi)\,T} \qquad (8)$$

$$t = -\frac{q}{(E' - H\varphi)} \log_e \frac{H - (E - H\varphi)\,T}{} + \frac{q}{E - H\varphi}(-\log_e H) \qquad (9)$$

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$$t = \frac{-q}{E - H\varphi} \log. \left(\frac{H - (E - H\varphi) T}{H} \right) \qquad (10)$$

$$\log. \frac{H - (E - H\varphi) T}{H} = - \frac{t(E' - H\varphi)}{q} \qquad (11)$$

$$\frac{H - (E - H\varphi) T}{H} = \varepsilon^{-\frac{t(E' - H\phi)}{q}} \qquad (12)$$

$$(E - H\varphi) T = H - H \varepsilon^{-\frac{t(E' - H\phi)}{q}} \qquad (13)$$

$$T' = \frac{H}{E' H\varphi} \left(1 - \varepsilon^{-\frac{t(E' - H\phi)}{q}}\right) \qquad (14)$$

Using v and s for the coefficient and exponent respectively of the last form of the equation, we may write

$$T = v\,(1 - \varepsilon^{-st}) \qquad (15)$$

This is the equation of a line passing through the origin and asymptotic to a straight line parallel to, and at a distance v above x.

Assuming values for v and s we can plot out a curve by the former equation.

Figure 7, plate I, page 289, is thus obtained by assuming a value of 40 for v and $\frac{1}{2}$ for s, and is seen to agree very well in form with the curves determined experimentally.

The derivation of an equation similar to (15) is given later for insulated wire, but the factors are somewhat complicated, hence the derivation is postponed until the effect of an insulating covering has been discussed.

Another problem, and one of more practical importance, is the law for the variation of the permanent temperatures which different currents are able to maintain in the same conductor. Here, of course, the heat generated just equals the heat lost by radiation and convection, or $H = L$ (16)

$$\frac{C^2 R}{J} (1 + \varphi t) = 2 \pi r l E T \qquad (17)$$

$$T = \frac{C^2 R}{2 \pi r l E J - C^2 R \varphi} \qquad (18)$$

For any particular wire under constant conditions of position, circulation of air currents, etc., all the quantities entering into the second term of the last equation except C^2 will be constant. T is therefore a function of C^2, and the curve representing the relations of C and T will be a parabola passing through the origin, and tangent to x at that point.

The only equations which I have been able to find for this relation did not take into account the change of resistance of the conductor for a rise of temperature.

This gives a form

$$T = \frac{C^2 R}{2 \pi r l E J} \qquad (19)$$

in which $T \propto C^2$ or $T : T' : C^2 : C'^2$

Any T' obtained from this proportion would be smaller than the true value as obtained by the above equation; for, while equations (18) and (19) have the same numerators, the former has a denominator less than that of the latter by $C^2 R \varphi$.

But $C^2 R \varphi$ is small as compared with the other part of the denominator; hence when C and C' are nearly equal we may use the above proportion without appreciable error.

In other words (since $H = C^2 R$) the heat developed, and consequently the temperature of the conductor, will vary as C^2 if R remains constant; but if R increases with C, then the temperature will increase more rapidly than as C^2.

If the change in R is inappreciable, then the error introduced by considering it constant will also be very small.

How this theory agrees with the results of the experiments is shown by the following table. The figures in the columns headed OBS. were taken from the cross-section paper those in the column headed CAL. were calculated from the largest observed T by the formula

$$T' = \frac{TC'^2}{C^2}$$

If we take T small and calculate for larger values; then, by the preceding discussion, the observed T' should be greater than the calculated.

In the table the smaller values were calculated; hence the observed T' should be smaller than the calculated.

The temperature taken as T in each column is marked by a dash under it.

Currents.	No. of curve on cross-section paper.	1	2	3	4	5	6
		Temperatures.					
9	Cal.	10.7	5.2	4.7	4.4	2.9	2.3
9	Obs.	9.9	5.6	4.6	4.7	2.2	1.8
12	Cal.	19.0	9.2	8.4	7.9	5.1	4.2
12	Obs.	17.7	9.5	8.0	8.0	4.2	3.5
15	Cal.	29.8	14.3	13.1	12.3	7.9	6.5
15	Obs.	26.5	14.8	12.9	11.8	6.8	5.6
18	Cal.	42.8	22.7	18.9	17.6	11.5	9.4
18	Obs.	38.0	21.7	19.2	16.1	10.3	8.4
21	Cal.	58.8	28.0	25.7	24.0	15.6	12.7
21	Obs.	53.3	29.0	26.7	22.5	14.6	11.7
24	Cal.	76.2	36.6	33.6	31.4	20.4	16.6
24	Obs.	70.0	37.0	34.4	30.4	19.6	15.9
27	Cal.	96.8	46.3	42.5	39.7	25.7	21.0
27	Obs.	96.8	46.0	42.5	39.7	25.6	21.0
30	Cal.	....	57.2	....	49.0	31.8	....
30	Obs.	....	57.2	....	49.0	31.8	....

In plate II, page 290, only four of the curves belonging to this set are given. The numbers on each curve indicate the table from which the data for plotting each was obtained. In working up the results, curves corresponding to each table from VIII to XXIII inclusive, were drawn. All the others have the same form as those given, and lie between curves XVII and XXIII. As some of the curves are slightly irregular, it was thought that to try to give them all would tend to confuse, so only four are given.

Another interesting phase of the last problem is to determine whether or not the absolute emissive power is the

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same for wires of like material but different diameters. By a simple transposition (of 18) we get a value

$$E = \frac{C^2 R (1 + \varphi T)}{2 \pi r l J T}. \tag{20.}$$

But instead of R, we may write $\frac{al}{\pi r^2}$ which substituted (in 20) gives

$$E = \frac{C^2 a (1 + \varphi T)}{2 \pi^2 r^3 J T}. \tag{21.}$$

This last expression is equivalent to one derived by Prof. Bottomley of the University of Glasgow, in an article which was published in *La Lumière Électrique*, for Oct. 4th, 1884. He obtains a form,

$$e = \frac{4 \; C^2 \sigma_t}{J \pi^2 d^3 (t - \theta)}$$ in which σ_t is equivalent to $a (1 + \varphi T)$ and $(t - \theta)$ to T, as used in this article. The two equations expressing the value of E are, therefore, exactly equivalent.

The experiments of Dulong and Petit, and of others, show that it is safe to assume that the power of radiation in different wires of the same material, placed in the same position, will be the same for equal areas, whatever the diameter of the wires.

The same was assumed to be true of convection, by the authors of some of the first articles which were written on this subject, provided, of course, the surrounding conditions remain constant. But experiments have shown, that even under the above conditions, this rule will not hold for convection.

A very good theoretical discussion of the matter has been given by Mr. Perenyi. It was first published in the *Electrotechnische Zeitschrift*, and later in *La Lumière Électrique* for Nov. 15th, 1884. I will translate from the latter paper, changing, at the same time, his symbols into those used in this article.

"If we refer to the formulæ of Dulong and Petit, combined with those of Peclet, we shall find that the heat lost by a conductor in an hour, is equal to

$$3600 \, H = (S' K' + S'' K'') \, 10^{-3} \, dl\pi, \tag{a}$$

an equation in which S' and S'' represent functions of the excess of temperature, and are expressions for the heat lost by radiation and convection ; K' is a cœfficient of radiation variable with the nature of the conductor, and K'' a cœfficient of convection which depends upon the form and the position of the same conductor.

For surfaces horizontal and cylindrical, we have, according to Peclet, per metre square and hour,

$$K'' = 2.058 + \frac{76.4}{d}.$$

The energy expended per second by an electric current of strength, C, is given by the formula

$$H = \frac{4 \, a \, l \, C^2}{4160 \, \pi \, d^2}$$

or the energy expended per hour, calculated for copper, is

$$3600 \, H = .022984 \; \frac{C^2 \, l}{d^2} \tag{b}$$

Putting $(a) = (b)$ we get, substituting at the same time the value of K',

$$7.324 \; \frac{C^2}{d^3} = 0.16 \, S' + S'' K'', \tag{c}$$

0.16 being the value for copper given by Peclet in a table of values for K'. It is sufficient to compare the results calculated by means of this formula, with those observed by Forbes, to realize the exactness of this last formula. These results are arranged in the following table :—

Diam. in m. m.	Intensity in ampères.		Ratio $\frac{C}{d}$		Calories per hour and per metre of length.		
	Observed	Calculated.	Observed	Calculated.	Radiation.	Convection.	Inter. heat.
0.58	9.84	10.337	16 96	17.91	0.1494	8.24	0.000031
1.22	23.04	23.314	18.88	19.11	0.3144	8.38	0.000139
1.58	30.26	30.323	19.15	19.19	0.4071	8.45	0.000234

We see that for copper, K' is very small relative to K'', we may, therefore, with sufficient approximation, neglect in this case the term K', which gives to equation (c) the form

$$7.324 \; \frac{C^2}{d^3} = S'' K''. \tag{d}$$

If T express the excess of temperature of the conductor, S'' is a function of this excess, and its value is given by the equation $S'' = n \; T^b$ in which n and b are cœfficients determined by Dulong, and which have the values $n = 0.3577$ and $b = 1.233$. We have, then, finally, by replacing K'' by its value for horizontal cylindrical surfaces in equation d,

$$\frac{C^2}{d^3} = \frac{0.3577}{7.324} \left(2.058 + \frac{76.4}{d} \right) T^b. \tag{e}$$

It is to be noted, that for excesses of temperature, comprised between 0.3° and 3°, T^b is sensibly equivalent to T; so that between these limits we may admit that

$$\frac{C^2}{d^3} = B' \; T \tag{f}$$

is sensibly correct, which conforms to Newton's law. But for great excesses, formula (f) is quite inexact because of the differences which T and T^b present ; thus, for 20° we have $T^b = 40.19$. Hence we should, in this case, employ formula (e). This formula may be written

$$\left(\frac{C}{d} \right)^2 = \frac{0.3577 \times 2.058}{7.324} \; d + \frac{76.4}{2.058} \; T^b \tag{g}$$

whence we may derive

$$T^b = \frac{9.977}{d + 37.12} \left(\frac{C}{d} \right)^2. \tag{h}$$

According as in this expression we neglect d as compared with 37.12 ; or 37.12 by the side of d, we arrive at the conclusion that $\frac{C}{d}$ is constant, or (perhaps better) that $\frac{C^2}{d^3}$ is constant ; neither of these values, however, being rigorously correct."

I do not think that equation (g) of Mr. Perenyi can be applied with any great exactness to the calculations for small wires, owing to varying atmospheric conditions, and to the fact that the experiments for determining K', b, n, etc., were made with bodies of larger dimensions than the wires under consideration. That the preceding formula is not rigidly correct, is also shown by the following table. In this table the column marked "T^b calculated" is made up of values obtained by the formula (g) of Mr. Perenyi, the data for this table being obtained from table XXIV.

No. of wire.	Diameter in millimetres	Current in ampères.	T^b calculated.	T^b observed.
12	2.004	17.0	18.4	10.8
16	1.25	13.6	30.9	21.4
18	1.01	14.2	51.4	40.9
20	.78	17.0	124.6	116.1
20	.78	13.6	79.7	65.9
20	.78	14.2	51.4	40.9
20	.78	7.2	22.0	18.2
20	.78	3.8	6.23	5.29
24	.49	7.2	57.2	61.3
28	.30	3.8	43.0	47.9

I do think, however, that Mr. Perenyi has shown conclusively, that the true ratio of current and diameter

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for constant T, lies between $\frac{C}{d}$ and $\frac{C^2}{d^3}$, approaching the latter as the diameter increases. And that his results are fairly exact is shown by the table given, page 366.

Though we have found a variation of about 50% in the temperatures for the same wire and current (getting for 26 ampères a temperature of 34, 36.1, 42.8, 79.0, 81.1, and 82.3), still, these largely different values were for extreme conditions, the smallest value being obtained with the wire out in a violent snow storm, and the largest, with the wire in a closed room heated by steam. An inspection of the results obtained for the wire in a closed room, shows a difference of only a few per cent.; hence, it is not so surprising that the values in the table, page 366, agree so well.

The true ratio of current and diameter, for constant temperature, has been the subject of several solutions, most remarkable in the dissimilarity of the modes of discussion and results obtained.

Mr. Perenyi, whose admirable solution we have given above, in an earlier article, which appeared in *La Lumière Électrique*, for March 22d, 1884, says (letting H = quantity of heat generated by a current in one second, and T_h the number of degrees it will raise a conductor of given weight and given specific heat), "at the end of n seconds the heat furnished will be $n\,H$ and the temperature $n\,T_h$. In reality, it will not be thus, because of the heat given up to the surrounding medium. This latter factor is evidently of some importance; but we may, in order to simplify the calculations, suppose that the heat lost per second is inconsiderable." * * * * *

"The error concerning the elevation of temperature thus introduced, is analogous to the introduction of a factor of safety into the calculations of strength of materials." But in carrying out the solution on the above hypothesis, Mr. Perenyi entirely neglects the time element introduced above, which is clearly incorrect on his hypothesis. The analogy to the introduction of a factor of safety, is also incorrect; for, as the experiments given in the first part of this article have shown, the factor neglected in the above solution, soon becomes equal to the whole of the heat generated, while the factor retained becomes zero. In computations for lightning rods, the solution would do very well, but for conductors for electric lighting or transmission of power where the current flows for hours, it is clearly incorrect. Thus, by an error in hypothesis and another in solution, a conclusion is reached which is approximately correct; *i. e.*, that for any T, the true ratio of current and diameter is $\frac{C}{d}$. Mr. Perenyi, himself, must have appreciated this, for his later solution given above, page 366, is comparatively as good as his earlier one is bad.

A similar result has been obtained, though by different solutions, by several others. Since the difference between this ratio and the true one is on the side of safety, no particular harm could result from its use. Not so, however, with the result obtained by some, that the ratio under consideration is $\frac{C}{d^2}$. The underwriters' rules limit the current to be carried to a certain number of ampères per square inch of cross-section of the conductor, which is equivalent to making the ratio $\frac{C}{d^2}$. The same rule is followed by some of the electricians for some of our principal electric light companies.

Since the true ratio is always between $\frac{C}{d}$ and $\frac{C^2}{d^3}$ we can easily see to what grave results this error might lead in the calculations for large conductors.

Of the earlier solutions, those most nearly correct were given by Prof. G. Forbes and Mr. W. H. Preece. They each determined theoretically, by practically similar solutions, that the ratio of diameter and current for any temperature should be $\frac{C}{d^{\frac{3}{2}}}$, the only error in their considerations, being that of assuming the emissive power of the wire proportional to the area; or, in other words, that the absolute emissive power is constant for all wires of the same material under similar conditions.

Prof. Forbes conducted some experiments on the subject, an account of which was given in the *Electrician*, vol. ix, page 497. Each of the three wires was heated to the same temperature (that of melting bee's wax) by increasing the current at intervals by small increments. This temperature having been reached, the current was then determined by the tang. galvanometer. The following table is taken from the article.

Diam in m. m.	C	$\frac{C}{d}$	$\frac{C}{d^{\frac{3}{2}}}$
0.58	0.984	1.696	2.229
1.22	2.304	1.888	1.709
1.58	3.026	1.915	1.523

An inspection of this table shows that the values of $\frac{C}{d}$ increase as d increases, while the values of $\frac{C}{d^{\frac{3}{2}}}$ decrease as d increases; hence the true ratio must lie between the two. Mr. Forbes, in an article which was published in the *Electrician*, vol. xiii, page 16, says: "My own view of the matter is, that while, of course, radiation is proportional to the surface, convection is not so, but is nearly constant for rectilinear wires of different diameters but the same temperature, and with thin wires, consequently convection is the most important factor; but for thick wires radiation, proportional to the surface, is the ruling factor."

The theoretical discussion given (page 364), reaches practically this conclusion, and the experiments of Mr. J. T. Bottomley, referred to above, confirm this opinion.

A fairly complete set of experiments on this subject, was made by Mr. W. H. Preece, an account of which was given in the *Electrician*, vol. xii, page 518. Mr. Preece in his article seemed to think that his experiments proved the ratio of $\frac{C}{d^{\frac{3}{2}}}$ to be correct; but an inspection of the tables taken from his article, shows that his experiments tend to establish the opinion that the absolute emissive power is greater for smaller wires.

(*To be continued.*)

A NEW SYSTEM OF TIME REGULATION BY ELECTRICITY.

A NEW method of regulating clocks electrically at a distance, based upon the patents of Messrs. Millard, Clarke and Eastman, is being introduced by the Synchronous Time Company, of Boston. The essential distinction between this apparently novel system, and those heretofore used, consists in its regulation of the *rate* of the clock by controlling and adjusting the centre of oscillation of the pendulum. Many devices have been put into use for controlling clocks at a distance through electric circuits. They have usually depended upon methods of moving or setting the hands at periodic intervals of time. In what are usually called "electric clocks" the ordinary time-keeping mechanism—train of wheels governed by a pendulum or a spring balance—is dispensed with, the hands being moved upon the dial by means of an electro-magnet, actuated at minute or other intervals by a current transmitted from a

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master clock. Any failure of battery, circuit, or action in the master clock, causes a certain loss of time in the subsidiary clock.

Other methods of electric time keeping are in use, in which ordinary mechanical clocks are synchronized at longer or shorter intervals by electric impulses from a controlling clock, setting the hands to correct time at the particular instant.

The method under notice, undertakes to do at a distance and at regular frequent intervals precisely what an expert does occasionally to a time-piece, that is, change its rate by adjusting the period of oscillation of its pendulum or balance. It may also be made to set the hands to the true time at the instant of regulation.

The system adopted by this company embraces a standard clock, which sends an electric current of less than one second duration over a wire extending to a series of ordinary clocks of any description, regardless of their distance from the standard clock or each other. The current is sent periodically, hourly or semi-diurnally as desired, and, by reason of the peculiar construction of the apparatus contained in each secondary clock it has no effect upon the latter if it is in correct time; but if its time be incorrect the current is directed through the mechanism in such wise that the centre of oscillation of the pendulum is changed and the running rate of the clock corrected.

The following illustration, figure 1, of one of the forms of the devices which the company is using, will convey a general idea of the system.

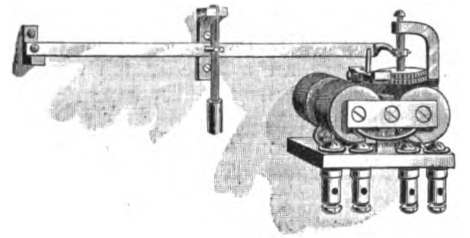

Fig 1.—Original Form of Regulating Apparatus.

It will be seen that the action of one or the other electro-magnet, will either increase or diminish the period of oscillation of the pendulum, the current being directed through one or the other magnet as the rate of the clock is either fast or slow at the time the electric impulse comes from the regulating clock.

Another form is shown in the following illustration, figure 2, which represents the application to the works of a Seth Thomas 15-day world clock. In this form, only one electro-magnet is used. A small pointed strip of brass just under the minute hand and attached to its arbor, is in position when the current is sent, to be engaged by an opening in the arm above it which carries the armature at its opposite end. As the arm moves down upon the point, the latter moves a sliding attachment supported by the arm, to the right or left; and this, by means of pawls, turns the wheel and screw one step in the corresponding direction, and the result is the same as that indicated in figure 1. In the first form the position of the pointed strip on the minute hand arbor directs the current through one or the other magnet, while in the second, simpler form, it simply determines whether the action of the single magnet shall raise or lower the centre of oscillation. The latter form, with trifling additions, can be made to set the hands if desired, and for some purposes is more convenient than the first.

The devices are placed upon a bracket about two inches square, in complete order to be screwed into the case of a clock, and the slight attachments which must be made to the suspension spring and frame of the clock are adjustable, so that the application to any description of clock is an easy task. They can be applied to any clock, mechanical or electric, and no stronger current is required to control a tower clock than for ordinary time pieces, although special sizes of the devices must be used for very large or very small clocks.

One application of the principle may revolutionize the present methods of regulation of clocks. By the use of one of these devices, a cell of open circuit battery and two keys, connected in the usual manner, the pendulum can be

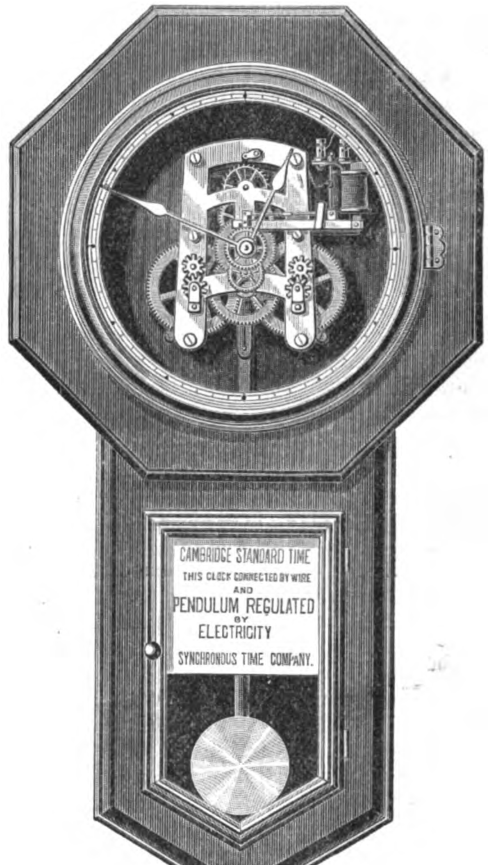

Fig 2.—Regulating Device—Synchronous Time Company.

regulated without opening the clock case, or interfering in any respect with the motion of the clock or pendulum. Pressure upon one key will increase the length of the swinging portion of the pendulum, and on the other key will decrease its length, in each instance a known and small amount, and obviously, repeated pressures can be given to produce whatever change in the rate may be desired.

Figure 3, shows the application of the principle to a marine clock—the rate of which can obviously be controlled in a similar manner to that employed in pendulum clocks.

Fig 3.—Regulation Device for Marine Clocks.

The system seems wholly novel, and should prove extremely useful to all who like to be on time.

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DYNAMIC ELECTRICITY.

BY CARL HERING.

(Continued from page 337.)

CHAPTER V.

ARMATURES.—(*Continued.*)

IN chapter IV. it was stated that the wire in the inside of the ring was a dead resistance, as there is no induction in it. Numerous devices have been used to render it active, among which are the following:

The pole pieces have been made to embrace almost the entire surface of the ring, by shaping the ends so as to project into the inside of the ring, as shown in figure 9.

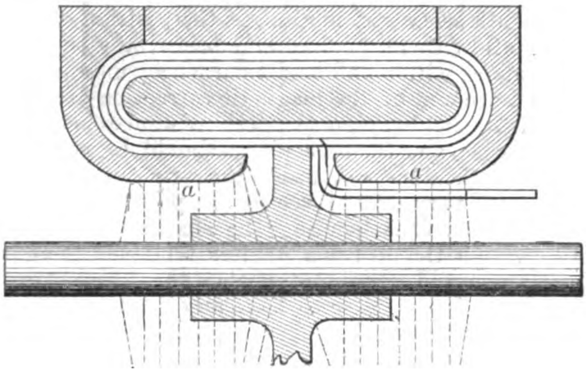

Fig. 9

This will increase the intensity of the lines of force somewhat, because it decreases the magnetic resistance of the circuit of the lines of force by increasing the active area of the two magnetic surfaces of the core and the pole pieces, between which the lines of force have to pass. For instance, if this surface is doubled by these pole-piece extensions it is equivalent to reducing the thickness of this air space about one-half, and thereby reduces its resistance to one-half. If the surface of the pole pieces is not over-saturated without these extensions, then by adding them, thereby doubling its area, for instance, the magnetism of the field magnets may also be doubled, provided the rest of the iron of the magnets be increased so as not to be over-saturated. This will double the number of lines of force, and, therefore, also the electromotive force generated. This method of making the wire active is, however, not to be recommended, for by adding these extensions the construction is complicated very much. It will be seen from the figure that unless the armature is very large in diameter, many of the lines of force would pass directly from the points *a a* of one of the pole pieces through the iron shaft to the opposite pole piece, which would evidently be leakage, and represent so much wasted magnetism. This leakage might even be greater than the small advantage gained by the extensions.

Another device for rendering the dead wire active, is to place in the inside of the ring an additional fixed electromagnet, whose poles are situated opposite to the other pole pieces, and have the same polarity as the corresponding pole pieces on the outside, thus making the wire on the inside cut lines of force in the proper direction. If this magnet is not very powerful it will short circuit magnetically the outside pole pieces, and in that case do more harm than good. This device, as the one above-mentioned, is impracticable, as it complicates the construction very greatly.

The best method, and one which has proved to be very successful in practice, is to make the ring flat, like a disc with a large hole in it, the pole pieces being then at the two flat sides. Electrically, this is equivalent to putting an extra magnet in the inside of the ordinary form of Gramme ring, as it renders both of the long sides of the rectangular armature coils active, and it has moreover the advantage that it does not complicate the construction. These so-called "flat-ring" machines are used very largely in Germany. The Brush armature is of this type, but has its coils connected differently. The most economic form of cross section of such a flat-ring machine would appear to be a rectangle in which the long side is two or three times the shorter; by making it much more than this the diameter of the armature is increased too much, or else the speed of those parts of the coils which are nearest the axis is too small.

In regard to the shape of the cross section of the ordinary Gramme armature core, no general rules can be given, as it will depend greatly on the general construction of the machine. The size of the cross section having been determined as described in considering the magnetic effects, it is well to make the length parallel to the axis as great as practicable and the thickness correspondingly small, for by doing so the required length of the wire on the armature will make less windings around the coil, thereby diminishing the self induction, the sparking and the thickness of the non-magnetic space between the core and the pole pieces, besides increasing its area. For the same reason, if it is required to increase the cross section of the armature, it is in general preferable to increase the length parallel to the shaft rather than to increase the thickness. For a given thickness, the magnetism increasing in proportion to the length of the armature core, it is evident that the electromotive force will be approximately proportional to the length of the core, other conditions being the same. This rule is merely a different statement of the rule given before, that the electromotive force is proportional to the magnetism passed through by the wire, it being understood that the iron of the armature and magnets is also increased in the same proportion, in order to be saturated to the same degree.

For a given cross section of the core the distance around the outside, that is the length of one winding, will be least, if the cross section is circular. It might therefore appear that this is the best shape of the cross section. If the magnets and pole pieces were of such a shape as to surround this circle as completely as possible, it would no doubt be an economical form; but at the same time it greatly increases the difficulties of construction, and as it is difficult to make the windings on the armature as smooth and regular, it necessitates an increased distance between the core and the pole pieces, which is a very bad feature. In general, the cross section will depend on the general style of the machine, and therefore the best shape should be found by choosing from calculations made for several assumed shapes.

The core of an armature should not be hollow, for it is evident that if the hollow core is not over-saturated, the length of the wire around it, and, therefore, its resistance, could be made less by making the cross section solid but of the same area of cross section of iron as before. On the other hand, if it is over-saturated when hollow, the magnetism will be increased by filling the hollow space within it with iron, thus making it solid.

The diameter of the armature should evidently be as great as practicable, for by increasing it other parts may be decreased. For a given electromotive force, all other conditions being the same, an increase in the diameter will affect the other proportions as follows: the speed may be decreased in the same proportion; the number of windings or the length of wire (in a Gramme armature), and, therefore, also the distance between the armature core and the pole pieces may be decreased in about the same proportion; or the latter may remain the same and the cross section of the wire increased, thus increasing the allowable current of the machine in about the same proportion; either the intensity or the size (volume) of the magnets may be decreased in about the same proportion; besides these, the distance between the projecting ends of opposite pole pieces may be increased in the same proportion, thus decreasing the leakage of magnetism; the

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length of the armature core may be decreased in the same proportion; the weight of the armature core will be increased in the same proportion, in the case of a Gramme ring with a certain cross section of core, while in the case of a cylinder armature the weight will be increased as the square of the diameter.

From the last two statements, and from the fact that the whole machine is sometimes increased in size with a larger diameter, it is seen that a limit is soon reached to which the diameter may be economically increased. In this case, as well as in the case of several other proportions, it is best to assume different values for the diameter, and calculate the other parts affected by it for each case, from which the best proportions can then be readily chosen.

The general rule in regard to speed or number of revolutions, is to make it as great as practicable. Its limits are, in practice, purely mechanical, as there is no reason, electrically, why the speed should not be infinitely great, except that the electromotive force of the Foucault currents and the resistance to changes of magnetism in the armature core are thereby greater, thus requiring finer laminations of the iron and softer iron in the core; but neither of these two will be as important in limiting the speed as the mechanical considerations. For a given electromotive force, all other conditions being the same, an increase in the speed will affect the other proportions as follows: the diameter may be decreased in the same proportion; the number of windings or length of wire on the armature, and, therefore, also the distance between the armature core and the pole pieces, may be decreased in about the same proportion; or the latter may remain the same and the cross section of the wire increased, thereby increasing the allowable current in about the same proportion; either the intensity or the size (volume) of the magnets may be decreased in about the same proportion; and in conjunction with this the breadth of the pole pieces measured on the circumference of the armature may be decreased if they are not over-saturated, thus increasing the distance between the projecting ends of the two opposite pole pieces and thereby decreasing the leakage of the magnetism between these parts; if the amount of magnetism is decreased, either the length, the thickness or the cross section of the armature core, or what is the same thing, the weight of the armature core may be decreased in about the same proportion.

The mechanical considerations for high speed are as follows: The armature should be as light as possible. Its diameter should not be too great. The shaft should be large in diameter to resist all tendency to bending. The length of the shaft between the bearings should be as short as possible to prevent bending, and, therefore, vibrating and causing a trembling of the machine. The bearing at the pulley end should therefore be between the pulley and the armature, not outside of the pulley. The armature and commutator between the two bearings should be as short as possible, and there should be no lost space between them or the bearings. The bearings should be long, at least three to four times the diameter of the shaft; and they should be made of some anti-friction metal; in no case should bearings be of iron when the shaft is of iron or steel, on account of the tendency of the magnetic attraction to increase the friction by pressure. The bearings should be as free from magnetism as possible, to avoid the generation of Foucault currents in the shaft, which are necessarily short-circuited through the centre of the shaft, and therefore may be very intense, and then heat the bearings. The bearings should be bored as true as possible and preferably bored at the same time with the pole pieces. They should preferably be fastened directly to the pole pieces and not bolted on a base plate on which the machine is fastened, as they are then liable to be out of line. The supports of the bearings should be as rigid as possible to prevent vibrating or trembling. It is of special importance in high speed that the armature should be rigidly connected to its shaft, and that it should be well bound to prevent bursting, or to prevent the wires from bending outward by centrifugal force, thereby coming into contact with the pole pieces; the tie bands around the armature wire should therefore be very tight and strong, and not too far apart. The armature should be as smooth as possible on the outside to prevent churning the air. The commutator should have as small a diameter as practicable to prevent too much motion between it and the brushes. It is preferable in cases of high speed to allow the shaft to have a slight lateral play of $\frac{1}{2}$ or $\frac{1}{4}$ inch, as it then distributes the oil better and is not so apt to cut the bearing. In this case the machine should be shifted on its foundation while running with its full load, until the shaft has a free lateral motion, as the position of the machine to allow this free lateral motion may be different when running with a full load than when running without a load, on account of the magnetic attraction of the armature and its field magnets. The distance between the armature core and the pole pieces should be precisely the same, on both sides, otherwise the armature will be attracted with very great force to one pole piece when the field is strong, thus bending the shaft and heating the bearings. As the oil has a greater tendency to get on to the armature and commutator when the speed is great, it is preferable in that case to have an oil catcher or screen of some sort between the bearing and the armature and commutator. The simplest form is to make a groove in the inside of the bearing with a dripping tube at the bottom, as shown at *a* in figure 10. Another simple and effective

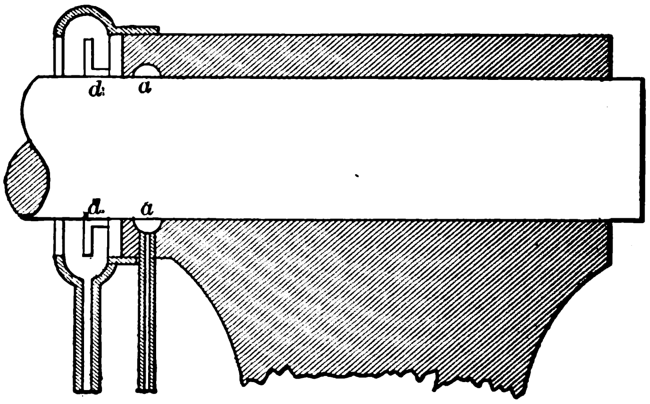

Fig. 10

device is to fasten a thin disc to the shaft near the inside end of the bearing, as shown at *d*, figure 10. The oil must pass around this disc to get to the armature, and as the disc revolves with the shaft the oil is thrown off at the edge by centrifugal force, and will therefore not get on to the other side. It may be caught and collected by a grooved ring and dripping tube, as shown.

Besides these considerations in connection with high speed, it is especially necessary to have the armature perfectly balanced mechanically, for if it is not balanced it will be liable to vibrate, which will be augmented by the consequent unbalanced magnetic pull of a strong field on the armature, due to the core vibrating, so as to come nearer to one pole piece and farther from the other. This vibration may become great enough to abrade the surface of the armature on the pole pieces, which is apt to cut the tie bands, resulting in the short circuiting and the total destruction of the armature. To balance the armature statically, place it, when quite completed, on two horizontal "knife edges" so that it rests near the two ends of the shaft. If on rolling it slightly it comes to rest in any position, it is balanced, if not, weights must be added securely, or better, metal must be removed if possible, so that it will come to rest in any position. It is often thought that this method of balancing is sufficient, but

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this is not the case, for an armature may be balanced perfectly on knife edges and yet it will vibrate when running at high speed. This will be seen from figure 11. Suppose there is an excess of weight at w and an equal amount at a diametrically opposite point w′ but at the other end. It will be balanced perfectly on the knife edges, but when revolving there will evidently be a tendency to distort the

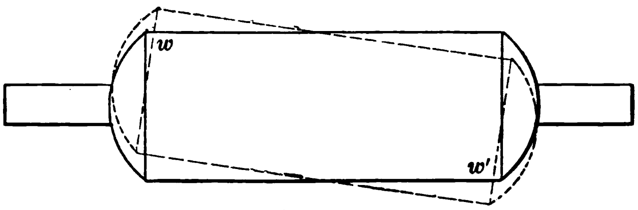

Fig. 11

shaft and armature as shown in dotted lines, which will tend to cause vibrations at the bearings. It is similar to the case of a bicycle wheel which may be balanced statically or when revolving slowly, but when revolving rapidly it will tend to vibrate, which is due to the weight of the cranks and pedals at two diametrically opposite parts at the two ends. In the case of an armature, it may be detected in several different ways, one of which is to revolve it rapidly while resting on two bearings, which are suspended and are free to move laterally.

An increase in speed represents a saving of material and a decrease of resistance in the armature and magnets; it is, therefore, a direct gain, both in cost of material and to a certain extent in efficiency, and consequently it is of equally great importance to take as much care with the mechanical details of construction as with the purely electrical proportions. It is much easier to build a low speed dynamo, as defects in its construction may exist which would be fatal to the successful running of a high speed dynamo. The aim of the technical engineer is to find the most economical proportions, while the aim of the manufacturer is to find the cheapest form. As the proportions and the cost of material both decrease with an increased speed, the importance of careful attention to necessary details of construction limiting the speed, becomes evident. Many mechanical machines are in continued daily use which are run successfully at a much higher speed than dynamos. The success of a certain well-known machine which is electrically deficient, is mainly due to the exceptionally high speed at which it can be safely run.

(*To be continued.*)

CARBONS FOR INCANDESCENT LIGHTING.[1]

BY ARTHUR S. HICKLEY.

It is not my object in this paper to enter into a lengthy description of carbons of various makes or to criticise what others are doing in that branch of electrical industry, but to offer a few remarks especially connected with the manufacture and testing of carbons, as far as I have been connected with the production of the same.

Incandescent lamps can be, and are, produced, which to a greater or less degree fill the requirements of the light-loving community (that is, as far as small lights are concerned) so as to induce many to invest large sums of money in electrical incandescent plants.

Many invested largely at first on account of their novelty, others as an advertisement; but as the novelty wore off, the consumer became interested as to the actual cost of running. In many cases they found their supply of lamps failed long before they expected, and they had to buy more, or allow dynamos, fixtures, and in many cases engine also, to lie idle. Then the question arose: Which are the best lamps to use, and what constitutes a good lamp?

A long-lived lamp is not always an efficient one; you may have a lamp which lives 1,000 hours, but costs you too much to run. Better have one which lives only half that time, but which remains clear, or comparatively so, to the end, and requires one-third the power to run it. Of course the consumers want both qualities, longevity and efficiency.

With a view of meeting these requirements, I commenced a series of experiments with carbon of every conceivable description of material and compound I could obtain; and although I recognized the fact that others, far more competent than myself, and with unlimited means, were working with the same object in view, I yet hoped a few crumbs might be left or overlooked which would fall to my share, and help towards the production of something better than was then upon the market.

It is not necessary to refer back to the many disappointments and failures of first experiences, for we have all been through that more or less. Suffice it to say, it soon became apparent that, as a general rule, an efficient carbon was not a long-lived one, and *vice versa*.

The question then arose, Why is that so? And after many experiments, both in baking, preparing and treating, exhausting with and without gases within the globe, I gathered some facts which I have the honor of bringing before you to-day.

I soon discovered what is now a recognized fact, that after reaching a certain point of incandescence the candle power doubled up with the increase of a very few volts. A 16 c. p. carbon at 100 volts, made of a certain material, became 32 c. p. upon the potential at its terminals being increased to 120 volts; again the E. M. F. falling to 95 volts reduced the candle power to 10. The size of the carbon had little to do with this in many cases. Thus a carbon of a certain size and 6 inches long, took 8 ampères with an E. M. F. of 100 volts to produce a 16 c. p. light; another of the same diameter and length took 4 ampères and 100 volts to produce the same light. But let us watch them burn; at the end of 100 hours the 8 ampère lamp was becoming dark upon the inside, the 4 ampère one remaining as clear as when new; at 500 hours the 8 ampère lamp was so black that the carbon could be seen only when burning, and gave a light externally of but 6 candles. The 4 ampère lamp still remained clear, but burnt out at 550 hours, and had given not less than 15 c. p. until the end. Upon breaking the 8 ampère lamp the carbon was found to be roughened all over, the roughness being evidently caused by small particles of carbon being thrown off, these particles not only causing the carbon to increase in resistance by their separation from the main carbon, but carbonizing the interior of the globe as mentioned before.

Carbons of the same material but of different diameter were then tested, all, I may say, being carefully examined before and after the tests through a powerful microscope. Two carbons were tested, each one being 100 volts, but one being twice as thick as the other. The thicker one gave a 16 c. p. light with the consumption of energy equal to 70 watts. The thinner one gave 40 c. p. with the same power, but the latter soon burnt out, and upon microscopic examination it was found that the fibres were cracked all over and were bent at right angles to the grain of the material and sticking out, as it were, towards the glass. I tried this upon a large scale and made a carbon as large as a No. 13 wire. It behaved precisely the same, but now the fibres were quite visible to the naked eye and stood out all over the filament as though it had become indignant at being abused and roughened, its coat resembling an electrified cat or a porcupine. With this carbon I could produce a light equal to a candle for every watt, with lamps of 50 c. p., but it would show fight and throw off its jacket. This was overcome at last in a manner I will explain later.

A carbon composed principally of the mushrooms formed

1. Read before the National Electric Light Association, at Detroit, Mich., Wednesday, Sept. 1, 1886.

between some arc-lamp carbons, forced through a small hole under great pressure, threw off particles as soon as they were rendered sufficiently incandescent to be efficient. Structureless filaments behaved the same way, especially when not treated in a hydro-carbon.

Much depends upon the manner in which carbons are treated; a rapidly deposited carbon is very hard and more efficient than one deposited at a lower temperature, which is soft and mealy; but the hard deposit is in lumps, which appear under the microscope to be united only to the main carbon at their bases; a hard, almost flint-hard, carbon (for there is such) is longer lived than a soft one, but the latter is oftentimes the more efficient. I refer here to untreated ones.

The fact then appeared to me that the soft carbon (porcupine description) with a jacket forced upon it which it cannot throw off or ruffle, would be *the* carbon.

So, having decided the first or base, the question then arose, With what sort of jacket should it be covered? I was not entirely satisfied with the treating or improving in hydrocarbon alone, and having exhausted, as far as I knew, the vegetable fibres, I tried animal of all kinds except the Chinaman's hair, which, I learn, some one has actually patented; and I found that, size for size, the animal carbons were behind the vegetable in efficiency, but they could be used much smaller, considering that they were not so disposed to disintegrate.

Experiments then showed that a carbon, which was exceedingly efficient but too soft, coated with a fine animal carbon, wonderfully lengthened its life and allowed of its being brought to a very high incandescence without destroying it.

The vegetable may be softened by an alkali and wrapped with an animal filament, and, after carbonizing, both are found to be united almost as one. In fact the vegetable has a coat upon its back which fits so tightly that it is compelled to keep its own on.

Again, in large carbons for 10 ampères a large amount of heat is produced, and if that heat could in some way be used before it left the carbon it would be beneficial.

It will be found that a large carbon built up of a number of small ones intermixed with glass in a very finely spun state and then wrapped, as described above, with any good animal carbon (of course this is done before carbonizing) will be very efficient, the carbon communicating sufficient heat to the finely divided particles of glass throughout its structure and rendering them conductors for the time being. A carbon of this construction appears to remain hot for a considerable time after the current is cut off.

Coating the vegetable fibre with another material, whether animal or vegetable, greatly increases the surface. If this carbon is heated to a high state of incandescence innumerable miniature semi-arcs appear to be formed all over its surface, wonderfully increasing its light-giving power.

Another important point to be considered is the preparation of the material before carbonizing. Many substances require little or none, but the greater portion must pass through a certain change first; some have a gelatinous or sappy substance contained therein, which if not removed or changed will cause miniature explosions within the material itself, and the fibres will be ruptured.

This must be most carefully avoided. A carbon which under the microscope appears to be a bundle of loose threads is of little value for incandescent lamps. You may treat or improve it if you like, and so cement the fibres together that to all appearances you have a good, hard carbon; but its backbone is weak, and an overcoat upon that, buttoned ever so tightly, provided it is made up of semi-detached particles (only cemented together at their bases and extremities, which is the case with a deposited carbon deposited in the usual way), will never make it long-lived. But it will be constantly increasing in resistance from the time it is put upon the circuit. If you have a fibre which, when baked, cakes or cements itself in a solid homogeneous mass, exhibiting no loose, hair-like projections, then you need not trouble about subjecting that material to any process before carbonizing. On the other hand, as I have tried to show, a good material which cakes or cements itself to itself and to any substance upon which it is wound or braided, will sometimes save the weaker fibrous material upon which it is so wound.

In baking, also, it is of the utmost importance that that process be not carried too far, for you want the life of the carbon in the lamp not burnt out in the furnace. But at the same time you must bake enough. It is possible to bake so little that the filament when removed from the molds, although to all appearance perfect, is virtually no conductor at all. Carry this a little farther and it becomes a poor conductor, but is not sufficiently changed to be of any use, for as soon as the current is forced through it it bursts with a snap and a ring, like steel wire. After this stage the conductivity increases to a certain point, when it again decreases, this time on account of the carbon gradually wasting away, and you are, in fact, burning the very life out of it. The point is to catch it just when it is the best conductor and before the unnecessary wasting away process commences. This can only be ascertained by repeated tests and great attention to the regularity of the heat. The heat should also be applied to the mold, crucible, or whatever form of receptacle you use to contain your fibres, as evenly as possible. The whole should be brought to a glow throughout, and at all parts at one time.

I have carbons which were baked so that their extremities, that is, where they are connected to the platinum, were overbaked and ruined, while the bow or upper part was scarcely done. Examining this carefully through a microscope, the ends were found to be weak and frayed out and useless, while the upper part, or bow, was solid, glossy, and appeared to consist of an entirely different material.

Again, some substances may be baked in bundles bound together, each one keeping its neighbor in place, while others would cement together in such a manner as to render them useless. Do not bake too many in the same receptacle at one time, or so much gas will be given out that partial combustion will ensue unless you have some means of pumping out the occluded gas as fast as produced. Some substance, such as camphor, placed within the retort will sometimes enable you to bake successfully a material which otherwise would be useless.

I have burning at the Russell House, lamps which contain a vegetable carbon surrounded by an animal carbon. The vegetable alone in this case would be useless, but the animal covering preserves it and renders a high state of incandescence possible without disintegration.

In fact it can, without injury, be maintained at so high a state of incandescence as to produce a bluish tint which enables you to readily distinguish colors.

The efficiency of the carbon in this lamp is a little over one watt per candle power.

I am manufacturing these lamps for the Jenney Electric Company, of Indianapolis, and find them very efficient.

THE LEGAL RELATIONS OF ELECTRIC LIGHT COMPANIES TO TELEGRAPH AND TELEPHONE COMPANIES AND THE PATENT OFFICE.[1]

BY ARTHUR STEUART.

As chairman of the legal committee permit me to present the following report upon:

First—The legal relations of an electric light company to a telegraph or telephone company in relation to the interference with telephone or telegraph business by electric light currents, and

1. Read before the National Electric Light Association, at Detroit, Mich., Wednesday, Sept. 1, 1886.

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Second—The relations of electric lighting to the patent system.

1. How far has a telephone company a legal remedy against an electric light company for interference with business due to a necessary incident of electric lighting, such, for instance, as induction?

In approaching this question we are met by one fact which exists in almost all cities of this country, and that is the fact, that the telephone companies are in almost every case in full possession of the field, and when an electric light company comes in and causes any disturbance of business, it is interfering with vested and established rights. But leaving this situation out of the question, because it is not a controlling one, we must fall back upon the principle that no man can use his own property (within reasonable limit) so as to injure that of another. I say within reasonable limit, because this doctrine can be carried too far. The demands of modern civilization are such that even if it were impossible to conduct a telephone and electric light business in the same district without very serious injury and obstruction to telephone lines, it can almost be said with certainty that the public would put up with very bad telephones rather than be deprived of electric lights. But, fortunately, this is not the case. Electric light wires and those of telephone and telegraph companies can be used in the same district, and if properly arranged will interfere to a very small extent with one another; but this harmonious operation of the two systems is only possible when some care is taken to prevent the difficulties, such, for instance, as hanging the wires far enough apart not to influence one another injuriously. If, however, an electric light company were to persist in placing its conductors so close to telephone wires as to cause injury to the telephone business, there would certainly be a remedy by way of injunction and damages at the command of the telephone company. Just here let me say one word on the subject of the oft attacked underground systems. A law which requires all wires to be placed underground would entail the adoption of some system in which wires of the different classes placed in the same subway could be so separated that they would not produce any inductive effect upon one another.

2. The second point upon which your committee is called upon to report is that of the relation of the electric lighting to the patent system. Some of you who may have some granger interest, will doubtless be surprised to hear me say, that to the patent systems of this and other countries alone, you and the people of the world owe almost everything in the shape of improvement in electric lighting which you now possess.

Such men as Wendell Phillips have said most truly, that to our patent system we owe our superiority over the periods and nations of the past. Many were the arts and processes, known to the ancients, of which we see the fruits, but the methods were lost, and why? Because there was no system existing, at the time that the inventors lived, which offered to them any inducement to disclose their secrets; they kept them, therefore, locked in their own breasts or communicated them only to a few chosen compatriots, all of whom were bound by a solemn oath, on penalty of their lives, not to disclose them. Some vicissitude of life swept all those possessed of the secret away at once, and they were lost. Under our system such a thing is impossible.

It is not my purpose to go further into a eulogy of the patent system of this country, for I know that most of you have had such practical and profitable experience of it as to need no argument from me to enlist you in an effort at its support and protection.

There is, as you are all very well aware, a large class of voters in this country who, from some cause, are violently opposed to the whole patent system as an element in our national life and policy, and, unfortunately, this class is so large and politically powerful that the halls of congress are ringing with attacks upon the system, and the courts of the country are seriously affected by the outcry, so much so as to have become technical and much less liberal than formerly in their construction of patents. And we, gentlemen, who from the standpoint of our daily life see the great, the immeasurable advantages that have been, and are being, derived from the operation of the system, are called upon to make our voices heard in its defense, to appeal to congress to support the growing industries of the country by protecting their developments, and to the courts to be liberal in securing to meritorious inventors the full benefit of their contribution to the knowledge of the world.

There are several special points to which I will direct your attention, and if the gentlemen think well of the idea, we would suggest that the weight of this convention be thrown into the scale to carry them into effect.

IMPROVEMENTS SUGGESTED IN THE U. S. PATENT OFFICE.

1. The burden of work that is imposed upon the examiners of the patent office has so rapidly increased of late years that the force now employed is entirely inadequate to accomplish what is assigned to them.

For years past the commissioner of patents has been petitioning congress to authorize him to expend some of the large accumulated surplus, about $350,000, which is lying in the U. S. treasury to the credit of the patent office, in the employment of a force adequate to perform the work daily pressing upon him. But so far his petitions have been unheeded. The department that suffers most by this lack of force is the electrical, because that one is most heavily burdened just at this time.

2. Another subject of special interest to electricians is a suggestion made by the commissioner of patents in his last message to congress, and that is a request that money be appropriated to erect an electrical laboratory for the use of the examiners in the electrical department, and for appliances. This is a very important matter to all persons applying for electrical patents, as it will afford facilities far greater than ever existed before for the examination and demonstration of electrical inventions, many of which require that the examiners shall be carefully instructed by the applicant, in order that a proper patent may be procured.

3. Some plan should be devised by which a higher class of men would be employed as examiners in the patent office. At present the men are fairly good, but with the exception of the principal examiners, few of them stay more than a very short time in the office. In fact it has become a custom that young men will go into the department, and after staying there for one or two years, will resign and establish themselves either in Washington or elsewhere as patent solicitors.

It is very desirable that the examiners in the patent office should be the very best and most experienced men that can be procured for the purpose, and when once secured they should remain in the position for a number of years.

To accomplish these results the suggestions that occur to us as most likely to secure them are to increase the pay and provide for the pension of examiners after a certain number of years of faithful service. In addition to the foregoing, it would be well that a system of annual or biennial examinations, such as exist in the navy, be instituted, because it is very important to the interest of applicants that examiners should not only be thoroughly educated and intelligent men, but that they should keep fully up to date in all matters with which they have to deal, both in science and law.

IMPROVEMENTS IN THE PATENT SYSTEM, RELATIVE TO THE TRIAL OF PATENT CAUSES, AND THE REDUCTION OF THE COST OF LITIGATION TO THE OWNERS OF PATENTS.

1. In the trial of patent causes great difficulty and loss of time is experienced, as well as great expense imposed

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upon the litigants by the necessity for the employment of experts, whose duty it is to elucidate the subjects in question for the benefit of the court, and to set forth the facts, as well as their opinions before it, in such shape that it will be able to fully comprehend them, and to apply to them the law for the purposes of decision.

It is the custom in this country for each party, plaintiff and defendant, to employ their own expert, who examines the case from their standpoint, and gives his opinion accordingly.

The reputation and ability of these gentlemen determine the cost to the litigant of their services, and it usually happens that their bills run into many hundreds and often thousands of dollars. For the purpose of overcoming this difficulty, it has long been the custom in the English courts for judges to call upon experts to assist them in the trial of patent cases. These experts are employed by the crown, and are not permitted to take employment from either litigant.

The benefit of this system is apparent. Instead of being compelled to encumber the record with a large mass of expert testimony, as well as charge the litigant with the high cost of the same, he will be enabled, by simply proving his facts, to go to a court of equity and argue his case before unprejudiced and sworn experts, trained in the art to which his patent appertains, who will instruct the court as to the facts, and leave it free to determine the law unencumbered by a mass of technical matter often little understood by the judges.

One of the uses to which these experts could be advantageously put would be to make them judges in interference cases, and other matters relative to applications for patents in the districts in which they were located, so as to afford additional facilities at reduced cost.

You have all, doubtless, had some experience in procuring legislation in congress, and have found that the best and most important measures will languish and be neglected unless some one makes it his business to keep the ball rolling, and unless all those interested in a measure will unite to have it taken up and favorably considered.

Some of these suggestions have been repeatedly before congress in the reports of the commissioner of patents, but as a prominent Washingtonian said to me some time ago, when I asked him why they had not been passed:

"What is everybody's business is nobody's business; they have, therefore, been overlooked because they were not brought prominently forward by some one who was personally interested."

We would, therefore, request that if this convention think well of the suggestion of this committee, they authorize the committee to prepare such bills for congress as will carry them into effect, and then when copies are furnished to the members they will individually use all their personal influence with their senators and representatives to have the bills passed and made laws.

In this way great good can be done by this convention, which will be of lasting benefit to all members as well as to all the inventors of the country.

LEGAL BUREAU.

We have been requested by the committee on bureau of statistics to submit a supplemental report to theirs upon one of the heads upon which they have touched, that is to say, upon the "legal department of the bureau," because they consider that it would very properly fall under the subject of the "legal relations of electric lighting to the patent system," which was assigned to your committee for consideration?

1st. What should the legal department be, and what is the need for its creation?

The legal department, as suggested by the committee on bureau of statistics, would be a branch of the bureau of information, to be in charge of a competent person skilled in electrical and patent matters, and to be always at the command of the members of the association, for information relative to patents upon machines or devices connected with electric lighting.

The need for the creation of such a bureau is very great, and is felt by many of you, and I am sure, when carefully considered, will be fully appreciated by all.

The whole field of electric lighting apparatus, from the dynamo to the lamp globe, is covered on every square inch with patents of greater or less strength and breadth.

You will be surprised when I tell you that there are at this time in force in this country, on generators and lamps (arc and incandescent) alone, something more than 1,750 patents, not to mention those on collateral details in addition, not included under these heads, and they are increasing with every week's issue.

It is, therefore, easy to appreciate how impossible it is for any one to enter the electric lighting business without running against some of these claims, and if no accurate information with reference to their real scope is in the possession of the person who comes upon them or is attacked by them, how is it possible for any of you to determine what is to be done when such a contingency arises? Of course it can be said: "Go to the best lawyer you can find, and get him to examine the matter and give you an opinion." Yes, that is an excellent method, provided you have got from five hundred to five thousand dollars to spend in that way. Then, too, almost all of you are licensees under one or more of these patents which are owned by individuals or corporations, that are living off of your earnings; and I suppose I would not be rash in asserting that not one out of ten of you have any idea whether the companies to whom you are paying royalties have any legal right to demand them or not. You went into the enterprise at first upon their assurance that everything was all right, and you have gone on without questioning the position of the parent companies, and will continue to do so unless some method is adopted by which you can procure at a nominal cost reliable information upon which you can act.

Your position is not a new one. Some twenty years ago the railroads of this country found themselves in very much the same position which you occupy to-day; they were creating a business, and as the amount of capital invested became greater and greater, and the dependence of that capital upon machinery of particular kinds became more apparent, these companies were made the victims of the cupidity and schemes of designing speculators, who would buy up a lot of worthless patents and then make a claim upon them for large royalties, claiming that certain appliances of vital importance to the railroad companies were covered by one or more of their patents, and the companies were presented with the alternative, either to settle or to fight; and it was a question as to which would be the more expensive. This system of blackmail became so burdensome that the companies were forced into a combination for mutual protection. They accordingly formed an association which is called the railroad association, the purpose of which was to employ counsel and economize the conduct of these controversies. To this association each member contributes in proportion to its strength, and from 1866 to the present time the saving to the railroad companies has been as 20 to 1, or for every dollar they have paid this association they have saved twenty by belonging to it.

The members of the association have the privilege of referring any question involving a patent to its counsel, by whom it is investigated and reported upon with promptness, and with no other cost than their annual subscription. If the counsel advises that the claimant has a just claim, he arranges with him the best terms he can for settlement, and calls upon the company to pay it. If he determines that the claim is invalid, he so reports it, and then if suit be brought the association undertakes the defense upon itself and bears all the cost.

A similar plan would supply a need to the members of

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this association. It might not be desirable at this time that the association undertake the defense of cases brought against the members and believed to be bad, but it is very desirable that a source be provided from which any of the members may be able to get an intelligent opinion upon any patent relative to electric lighting apparatus that they may desire, and that at the small cost of membership to this association, either for the purpose of resisting demands upon them or for intelligently examining enterprises for investment.

Let any member of this association who is a purchaser from the manufacturers of electrical apparatus calculate the actual cost of construction of the apparatus he is buying, and compare it with the price he is paying, and determine what percentage of profit is made upon these goods; and then let him consider that this large profit and high price, in the average quite one hundred per cent., and in many cases five hundred per cent., is consequent upon the possession by the manufacturers of patents of very questionable validity, some of which are certainly void, and which, if declared so, would reduce the cost of these goods, and hence increase the net profits of the sub-companies in due proportion. I do not think I am stating the case too strongly when I say that if these patents were examined critically, and placed upon a true and proper basis, that the average cost of apparatus could be reduced at least 20 per cent. If such were the case, and the saving thus made by all the members of this association were added together, they would certainly amount to considerably more than a hundred thousand dollars. It requires but a comparison of this sum with the cost of maintaining this department, which would probably be some four or five thousand dollars per annum, to illustrate its economy.

2. The plan upon which such a department should be conducted would be to select a suitable person as general counsel for the association, put into his office copies of all the American and foreign patents pertaining to electric lighting, and such other books as would be desirable; or, if he were located in Washington, he could be near enough to the patent office to use the records there with facility.

A committee should be appointed, of which he and the custodian of the bureau of information should be members, with such other persons as might be selected, whose duty it would be to hear and consider the reports of the counsel upon cases examined and to determine whether his reports were correct. These reports, when acted upon by the committee, should be filed in such a manner as to be at hand whenever needed for reference.

Your committee cannot too strongly urge the establishment of such a bureau as of inestimable advantage to the members.

THE OPERATION OF MOTORS FROM ELECTRIC LIGHT AND POWER STATIONS.[1]

BY T. COMMERFORD MARTIN.

When I find that more than one hundred electric light companies have the words "and power" in their titles, I come to the conclusion that they mean something by it, and the drift of the paper I had the honor to present, as a proxy, before the association last February, on motors, was that it is worth the while of electric light men to pay attention to the questions involved in the distribution of power electrically. The "faith" exhibited by a high sounding corporate name can be profitably seconded by "works." Electric light men, for the reason that they, more than any others, are familiar with the modern problems of heavy electrical engineering, are the best qualified to introduce electric motors to public notice, and the further I investigate this subject the more deeply do I become convinced that there is hardly a locality where an electric light plant exists in which also electric motors cannot be installed remuneratively.

At the present time, the feeling with regard to motors is in many quarters so sanguine that it amounts to a "boom." Now "booms" are just as bad in their way as inflation of the currency, or any abnormal display of high spirits and strong imagination. But in the case of electric motors, the "boom" if there be one, has been slightly delayed. Historically, the electric motor anticipates in practice the electric telegraph, the electric light, the telephone and the storage battery, yet to-day it has less importance than any of these, except possibly the last. I venture the opinion that in the near future the relative prominence of these applications will be somewhat changed. Perhaps it is well that the greater perfection of the electric motor has been delayed, and even to-day is tardy. Its ultimate success has depended upon improvements in primary batteries, in secondary batteries, in dynamos, steam engines, boilers and furnaces burning cheap fuel, upon improvements in wires and in line construction, upon the development of modern ideas of urban convenience, and in no small degree upon the multiplication of small industries requiring power minutely subdivided, yet, like the eastern genii, ready at beck and call. I might, indeed, assert that the electric motor had, for its full fruition, to await the growth of the modern idea of centralization, through whose influence we are led to depend on central stations and agencies for light, time and heat; ice, water and air, "patent inside" newspapers, associated press despatches, and almost every one of the comforts, conveniences and nuisances specially distinguishing modern life from that of the days gone by. The electric motor is the latest, in many respects the most effective realization of the idea of centralizing productive effort with the view of gaining the greatest good for the largest number, yet leaving the individual a larger freedom than he ever enjoyed before. Mr. Henry George, the economist and social reformer, told me the other day that he feared electricity would be monopolized like other forces, and that though the electric motor would enable manufacturing producers to work cheaply on a small scale and widely scattered, it could only mitigate the evils of the private ownership in land that now crowds our working population into dens and hives near their places of employment. I am a little more cheerful and optimistic than he. While I am not one of those who arouse Mr. Matthew Arnold's anger by looking upon railways, cheap postal service and electrical applications as marks of the millennium, I do prize them, especially electricity, as means to the end of gratifying the instinct of man for expansion, and affording him the opportunities that enlarge and secure his existence.

That way lies the social philosophy of the electric motor, whose wires can be run through a key-hole, into a tenement or out through country districts, and whose uses are common to all in need of power. Now a few words on the practical side of the subject. At the present time the application of the electric motor divides itself into two departments, both of interest to electric light men, that of street railways and that of industrial work. A brief glance may be taken at each department separately, and, first, at that of street railways. As nearly as I can estimate, with close figuring on each of the roads, over a million passengers have already been hauled by electric locomotives in America, while the number in Europe far exceeds that. Such a fact is significant in itself in these days of rapid change of system and greater attention to comfort in travel. Probably we shall not have to wait for an epizooty in the car stables before we see a very general adoption of electricity in the propulsion of street cars. The Baltimore Daft electric street railway, over which many of you traveled in heavy slush and rain last February, is now in its second year of operation, without any electrician in charge, and contemplating an extension. The cost of electric power per day is $12, as compared with $18 for

1. Read before the National Electric Light Association at Detroit, Sept. 2, 1886.

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horses under the old system; and the cost per passenger last year was .83 cents, or about half, as compared with 1.55 cents in 1884.

The Daft system is in use at Revere Beach, Mass., and is now being introduced on the street car lines at Los Angeles, Cal., and elsewhere. The Van Depoele system of electric locomotion is in use in or under contract for several cities, among which may be named Minneapolis, Montgomery, Ala., Windsor, Ont., Detroit and Scranton, Pa., and Appleton, Wis. The figures, will, I hope, be presented by Mr. Van Depoele himself, showing results of great economy as compared with mule or horse-power traction. In Philadelphia, Mr. H. M. Schlesinger has a good system operating on a half-mile track, and one that will be introduced at more than one point early next year. The Bentley-Knight system, that was successfully tried in Cleveland last year, can now be seen in operation at the Providence Locomotive Works, Rhode Island. And last, though very far from least, is the system of Mr. Frank J. Sprague, who has worked out his inventions and plans with a thoroughness and ingenuity that must awaken admiration in every one. I am not at liberty just now to explain the details of the system: they will probably be made public in a short time.

To show what is thought of elevated electric railways, I may quote Prof. Henry Rowland, the distinguished physicist of Johns Hopkins University. As to this system he says: "Altogether there is no doubt in my mind that Mr. Sprague's method of working motors for electric railways is thoroughly scientific, and that it has many advantages from a practical point of view. It is also decidedly more economical than any other that has been brought to my notice, and will certainly accomplish what is required in such a case, namely, the moving of a train of cars from one station to another in the least time, with a given maximum speed, and with the greatest economy of power and least wear and tear of machinery." I should add that Mr. Daft is also resuming his work, with heavier motors, on the New York elevated roads.

Mr. Sprague has for some time past had a car propelled by his motor running on the Thirty-fourth street branch of the New York elevated railroad, ten blocks away from the generating station. I mention these facts because many minds are at work on electric street railway problems, because the enterprise will be carried out, and because electric light men operating large stations, as many of them now do, know that they can easily generate and handle the large currents necessary. In fact, if they will seize their opportunities, many of the street railways will soon be operated electrically by electric light men. The whole new motor business is legitimately theirs, just as the electric light field and that of telephony opened up new careers to telegraphers. In electricity, we rise on the stepping stones of our old selves to greater things. Some electric light men will naturally say that they are at present as busy as they need be, and it is true that the electric light men has yet to be evolved who can say, with Walt Whitman, "I loafe, and invite my soul." Still, I think that most of you will in a few years be interested directly in street car operation.

The second department in which motors are being used to-day is the industrial; although, even already, the industrial work is subdividing itself. The number of small electric motors in use to-day industrially in this country may be put at certainly far beyond 5,000. Of the old, familiar Griscom motor, several hundreds have been put in use: of the Stockwell motor, about 1,000 have already been called for; Daft motors are in use in New York, Boston, Worcester, Providence, Coney Island and other places. Sprague motors are running in New York, Chicago, Boston, Pittsburg, Des Moines, Elgin, Oskaloosa, Shamokin, York, New Brunswick, Fall River, New Bedford, Milford, Taunton and Lawrence, Mass.; and there are also a great many Brush, Baxter, Pendleton, Bergmann, Keegan, Edgerton, Reckenzaun, Ayrton and Perry, Diehl, Roberts, Crocker and Curtis, and other motors in use all over the country, on work of the most varying nature. A few exemplifications of their use by electric light companies will perhaps be interesting. In Philadelphia the Brush company is running about 250 Stockwell motors. The small motors are chiefly on factory sewing machines, but some are on fans and jewelers' lathes. They are generally giving satisfaction, and if the company could only get its wires to the places wanting motors, the number in use would be quadrupled. Mr. M. D. Law, the electrician of the company, who has charge of this department, operates 18 of the small motors with the power required for one arc light, if they all of them run together at one time; but in practice he has no trouble in running from 30 to 40 with the same power, as they are never all on together. The charge for the current is $5 per month for the first four motors, and then $1 per month for each additional motor. All motors are wisely sold outright, the company only renting the current for them. At the Brush-Swan station, Cheyenne, Wyoming, Mr. E. P. Roberts is building his own motors and finding a wide variety of use for them. One runs an evening paper, another a gunsmith's lathe and emery grinder, and two others cut up sausage meat for butchers. In the case of the gunsmith, the charge is ten cents per hour per horse-power. The motors are run from Brush storage batteries on the day incandescent circuit, and at night from the dynamo, the potential being 100 volts. The Brush station at Baltimore has been putting out motors, chiefly of the Baxter and Edgerton types, quite extensively. The Baxter motor there has been running on a great variety of work, on arc circuits, with good profit, and is said to be very economical of power while regulating with the utmost closeness under all variations of load. At Germantown an Edgerton motor is running a Gordon press most successfully. In Detroit the Brush company is also running several motors.

At Des Moines, Ia., the local Edison company is running a number of Sprague motors. The motors there are sold outright and the current is generally charged per meter. One of these motors, of 3 h. p. is used in a livery stable to run the elevator for hoisting the buggies and hay, for pumping water and for brushing down the horses. One runs a scissors grinder's outfit, one a drug mill, one a polisher in a plating establishment, and, curiously, one the generator in the telephone exchange. Several elevators now run by water will have electromotors this fall. Mr. F. H. Whiting, the manager, says: "I think that the motors in reasonably large towns can be made to go a long way to the paying of running expenses of those stations that have to run all the time, as in the incandescent business."

At New Bedford, Mass., seven Sprague motors have already been installed within a short time by the local Edison company, and are now used in silver plating works, on ice cream freezers, on coffee grinders, bookbinders' cutting-presses, on a hydro-extractor in dye works, and on a hair picking machine. These motors earn easily altogether about $40 a month, on the regular incandescent circuits, the current being supplied at lamp rates, 1¼ cents per 16 c. p. lamp hour, and measured by meter.

In Boston, the Sprague company is running a large motor service on a circuit embracing a three-quarter mile radius from its station in Bumstead Court, the motors ranging in capacity from ½ h. p. to 7½ h. p. To enumerate all the kinds of work done would be to mention most of the machines for small work heretofore driven by steam engines or foot power. The motors are sold outright to the customers, and $125 per horse-power per annum is charged for the current or power service. For elevator work, there are special rates depending upon the average use by the consumer. The amount of average consumption is determined by ammeter and voltmeter, and from that determination a contract price is made. The intermittent use by the consumer is found to be an important factor in

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supplying power, as not more than 37 per cent. of that sold is ever called for at one time, so that, allowing for the loss in transmission, at least double the engine service can be sold, provided the power is distributed in small quantities. From actual tests made by one company, it appears that some few of the averages of power consumed run as low as 14 and 15 per cent., and Mr. Sprague tells me that the higher average of from 33 to 37 per cent. will apply not only to small powers, but is absolutely true of large powers, such as 40, 50 or 100 horse, where a number of these are operating together from a central station.

As an evidence of the feeling in Boston on the subject of motors, I may mention that the Merchants' Electric Light and Power Company, running 800 Thomson-Houston arc lamps, has voted to adopt, and is now equipping for, the Sprague system. At Springfield, Mass., another actual electric power station will be established. The Springfield Steam Power Company, heretofore transmitting power by belting, shafting and wire cables, has now decided to distribute power by means of electric current, as giving a better and more economical service, as well as increasing the distance at which it can work. The change is being carried out at the present hour.

In New York a great many Sprague motors are in use. A large number of Daft motors have been in operation there for a considerable length of time, and I know from actual personal inquiry and observation that you could not get these customers to abandon the use of their motors. One instance deserves special mention. Mr. E. B. Stimpson, in Spruce street, well known as an inventor and manufacturer of fine machinery for the shoe and stationery trades, has for about a year been running three floors of his workshop with a Daft motor. Some of the machines, belted to the shafting on the various floors are quite heavy—drills, lathes, planers and the like; others are extremely fine and delicate; but for all of them, Mr. Stimpson tells me, the electric power has been sufficiently steady. He had formerly a 10 h. p. vertical engine, with boiler on the top floor of his building, and had the usual trouble with engineers, coal, ashes, dust, oil, vibration and great heat in summer. Now, in striking contrast, a little 6 h. p. Daft motor stands on a small wooden base, close up against the disused boiler and engine, making so slight a noise that it in no way interrupts conversation. The motor runs the day through, and all the attention it gets is a very occasional visit and wipe on the commutator from a motor man, who also has charge of a number of other motors all around the neighborhood. Mr. Stimpson pays $12 a week, and I doubt if there is a manufacturer in New York to-day better pleased with his power than is Mr. Stimpson with the electric motor he has been using so long and with such good results.

A great many motors to-day are operating very successfully with primary batteries, and that field will grow.

In the incandescent business, the plant must be kept running all the time, so that the consumer can always have his light when he wants it. Hence I look upon motors as the most important auxiliary to-day for incandescent lighting, and I think that in many an arc station, too, they will solve the financial problems of day lighting. But whether that be so or not, what I have said shows, I think, that the day of the electric motor is upon us.

WIRE JOINTS.[1]

BY C. C. HASKINS.

JOINTS, splices, connections, by whatever name we may designate them, play an important part in all vehicles of electricity, from that conductor which carries the pigmy talking current of the telephone or that other feeble weakling which from the manager's desk rings up the nodding office boy, on the one hand, to the carrier of a giant power which lights a thoroughfare, or successfully combating the forces of nature, attracts the metal and repels the dross in a valuable ore, on the other.

The influence which one of these junctions may exert for good or evil is varied by an element in the question liable to be overlooked by a casual observer. A connection which will answer all necessary demands in a burglar alarm wire or a call-bell circuit, the simplest of all connections, a bell-hanger's joint, might be an element of untold annoyance and loss if placed in the path of another form of current. In telephone work, too, an imperfect joint, provided it is not loose enough to set up a microphonic action, is usually considered a matter of comparatively small importance, provided the subscriber pays his bills promptly.

In both these cases the original outlay for mechanical power is so slight, the weight of copper so small, the entire combination so simple, that a renewal of the plant would be hardly more than the re-insulation of an ordinary central electric light plant, and hence of little consequence.

The average electric-light man is a graduate of some one of the schools alluded to above. He comes, usually, from either the telephone or the telegraph department of electricity, and naturally brings with him the ways and ideas which pertain and belong to those enterprises. The unlearning, the forgetting of certain of these ways and ideas, the reteaching of such employés is really a matter of more labor and less progress than if the scholar were one who had never been a toiler in any electrical field.

The telephone man will tell how many hundreds of joints he has made without even scraping the wire, and that all the connections on the switch-board where he learned the business were fastened without soldering, and no "lines ever worked better than they did in the old N. G. Exchange."

And the telegraph man boasts of the thousands of joints he has made where he twisted a No. 9 wire so tight that years afterward, when Doran, or Bristol, or Pat Whalen renewed the line, in each of his joints that was opened they found the line of contact between the two wires as bright as the day it was put there, perhaps, before the war. It is hard teaching old dogs new tricks.

The telegraph people have an advantage over the electric light people in this: Their lines are all run in a way to enable an electrician seated at some telegraph centre like Chicago, New York, New Orleans, or San Francisco, to connect with any one of these which is working unsatisfactorily, study its symptoms and prescribe for the disease, no matter how far away. An expert at the terminal of the cable connecting two continents will measure the distance to a fault in the line and locate it so nearly that it is picked up with little difficulty.

In a telegraph line an amount of resistance equivalent to that of one relay in the line would be readily compensated for by a slight increase of battery power, or still more easily by the adjustment of the instruments in the line. Such an addition to the resistance of an electric light circuit might be almost equivalent to shutting down the plant. On the other hand, a current which the telegraph service requires would be effectually stopped by a resistance to which a dynamo current would pay little heed.

Experience shows that a bad joint is more readily found by using a small battery than a larger one. Such a joint on a line having, for example, 25 cells of battery will occasionally open the line and thus cause annoyance, while for the most part of the time the line will remain closed. Now if while it is open the twenty-five cell battery be short circuited with a thirty ohm relay in circuit, when the battery is again opened out suddenly the line will close through the imperfect joint.

Several explanations of this peculiar phenomenon have been suggested. It has been claimed that a mechanical closing of the fault is produced by the metallic expansion due to heat. Another suggestion was that the two electrical

1. Read before the National Electric Light Association, at Detroit, Sept. 1, 1886.

conditions either side the break, being opposite in character and mutually attracted toward each other, that these acted magnetically and closed the gap by attraction.

In all this matter of insulation and conductivity we must bear in mind that these terms are only relative; and that while a moderately low insulator answers every purpose for a battery current, the magneto current will overstep the obstruction; and when we have increased the insulation till this will no longer permit the passage of this force of higher potential, we have only to discharge the spark from a Holtz or other frictional machine to see that what was but just now an insulator has become a conductor. This spark will go readily through a silk hat or the sole of a dry boot. Taking an extreme, what are we to think of the insulation resistance of a layer of dry air, a mile or more in thickness, through which a thunder-bolt descends from clouds to earth?

It may be claimed that the water-drops in a storm serve as stepping-stones for the current in this case, but it must not be forgotten that the same condition of affairs does not exist in a snow-storm, nor in many instances where heavy discharges of lightning occur just previous to a summer shower.

One thing more in this line of digression. A joint having more than the normal resistance of the line, like any portion of the wire which is too small, will always show heat in proportion to such obstruction.

The only instrument known to the average electric light man, for any form of testing, is the magneto bell, the introduction of which into this service for such purposes I look upon as a most lamentable mistake, in that it is incompetent for good, while it is abundantly powerful for mischief by misleading those who rely upon it. But for the existence of this imbecile machine, I feel certain that long ere this the inventive genius of electrical scientists would have given to all a cheap, comprehensive combination, capable of making all necessary tests for any form of electrical plant. As it is, its application to a line can only give one of two answers: the bell rings or it does not. If it rings and the circuit through which the current flows is short, why, it rings! If the circuit is a long one it may ring when there is an actual insulation of thousands of megohms, and possibly ring louder than if there was a leak. I know of no practical way by which the amount of leak can be ascertained by the use of a magneto bell.

The old saw about the danger of a small amount of learning is sometimes applicable to the employé in charge of an electric light plant, however good his intentions are, however ready he may be to learn. There are certain acts which he performs which naturally lead up to certain results he does not always know, and often does not care why. Like the fireman in the gas works who said, "I don't know nothing about your hydrogin nor your oxogin nor your nitrogin, but I know when I puts coal under the retorts the holder goes up." Feeling, too, as he does, that all the knowledge he has acquired has been through his own unaided efforts and ability, he quite naturally bottles up his experience and allows his successor to accumulate a fund of information for personal use in his own way.

Since my attention was first drawn to electric light circuits, I have had no end of controversies with these, my co-laborers, many of whose names I have seen catalogued in popular lists as electricians, men who talk familiarly of "computators" and "low currents," "induction" and the old-fogy idea of using "sodder" in joints. These disputations have not always resulted in conviction, but when I have succeeded, by stubbornness, in convincing my learned peers, something like a "before and after taking" picture has usually proved the best argument.

During the first six months of my experience as inspector, I visited a plant and made the acquaintance of the electrician in charge, who informed me, with a deal of satisfaction, that he "knew all about electricity." This knowledge he had acquired in a year and a half, while in charge of a plant of twenty-six lights. It goes without saying that he had invented a complete system of electric lighting which was soon to astonish the world. His ability was demonstrated by the condition of his circuit. In this there were ten or a dozen wire joints, none of which had ever been soldered, and all were more or less loose. One near the dynamo was so imperfect that the two loops of which it was made rattled like the links of a chain. The circuit had three sizes of wire, and in several places was fastened to the wood work with wire staples. The changes which I deemed necessary were the cause of much discomfort to the proprietor of the plant, who had great faith in his "electrician," and the inspection fee was grudgingly paid. In less than a week I heard from the owner of the plant, who said that the saving in coal would pay all the expenses in two or three months, and that they "were getting much better light now with a much slower running dynamo." A still more striking illustration of the necessity of good joints is part of my experience. In this case a central plant having been in operation some two or three years had gradually deteriorated until less than half the guaranteed number of lights could be burned on the circuit, and these were not up to the normal light standard.

It was one of those plants which are constantly undergoing changes; lamps, discontinued at one point, were cut in at another, to suit the whims or necessities of consumers, until the entire three miles of wire was but little better than a scrap heap line. From that three miles of wire over one hundred connections, good, bad and indifferent were overhauled, inspected, and renewed where necessary. How the dynamo had been able to maintain as many lights as it did, was a mystery. The entire circuit, cold, measured over three hundred ohms. The line after the necessary changes were made, came back to its normal condition, and is today performing its proper functions.

There are two requisites in a wire splice which, I hold, are too frequently ignored. A badly shaped joint is exceedingly difficult to insulate properly, and an uninsulated joint in some cases may be an element of extreme discomfort both to patience and pocket when the inevitable electrolysis gets a foothold through the intervention of moisture, and oxidation sets up abnormal resistance. A joint, then, should be not only perfect as a connection, but perfect as to insulation.

The greater portion of the joints in the case mentioned a moment ago were of that class of abominations known to all of us as "connectors." A brass sleeve to receive the wires and a couple of iron screws to hold these in place. In this combination we have the metallic elements necessary for a local battery, small, it is true, but abundantly capable for mischief, and with every heavy dew, with every fall of rain, we have the necessary fluid to set our battery in action. This form of joint is usually left uncovered to render it handy for testing or cutting in loops.

Electrolytic action introduces an oxide, which coats the inside of the loose fitting sleeve, until the total carrying capacity of the joint is the contact between the iron screws and the wire, with an occasional touching in the sleeve, providing the screws are driven home with a force capable of twisting off their heads. Otherwise, where these have worked loose, an arc has sometimes been established, melting off the conductor, and waking up a fire department.

Now let us look at the condition of affairs on such a circuit. Suppose the capacity of the plant is 20 lights. To insure good work a wire equivalent to a number six American gauge is necessary. Reduction in the carrying capacity of a joint is equivalent to the introduction of a smaller wire in the circuit, which means reduction in the current, reduced illuminating power, more coal and an average increased amount of profanity from lamp trimmer to proprietor, and dissatisfaction on the part of the consumer. For the flow of current is the quotient of the electromotive force of the generator, divided by the resistance of

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the circuit, and the greater the divisor the smaller will be the quotient. One bad joint in a line may offer more obstruction to the passage of a current than all the lamps on the circuit put together. Such an amount of resistance on a telegraph or a telephone line, however, would be a matter of very minor importance.

It is sometimes easier to diagnose a case than to prescribe for its cure. I have stated that I consider it essential that there should be abundant carrying capacity in a joint, and that this should be protected by an insulating covering. The first consideration is satisfied by any form of joint which is soldered ; but by the presence of a second metal, a brass or iron connector for a copper wire, or a copper or brass connector for an iron wire—these become battery elements in combination, and dampness from whatever cause is ever ready to complete and set the battery to working.

The American telegraph twist joint, closely and firmly made ; the Britannia joint, in which the two wires, turned at the ends to prevent slipping, are bound together with a third smaller wire ; the scarfed joint ; the parallel copper tubes which receive the wire ends and are then twisted ; and the copper sleeve which is provided with openings through which to solder the wire ; all these are good when soldered, to fulfill the first requirement of a complete joint ; and the one of all these which permits of the most thorough insulation by wrapping, combined with sufficient strength, is the most perfect joint.

On the other hand, the most perplexing joint, and one which has given our electric light people the greatest annoyance, is that which serves as the junction of the overhead and underground wires, where the latter are covered with lead and the former is of the "underwriter" or painted wire variety. The ease with which one of these joints will absorb moisture and bridge over from the underwriter wire to the grounded metal covering of the underground wire, and so drop the insulation resistance below a safe point, or, aided by a second ground elsewhere, set up an arc and a row among the fire worshipers at the same time, is both provoking and astonishing.

There seems to be a deal of satisfaction in a quiet way to a bit of spun fabric, when it can find a trifle of moisture somewhere and carry this to where it is not wanted by capillary attraction, and thus set at naught all but the most carefully prepared underground joint work. The simplest and most thorough remedy for this trouble is to carry the underground wire far enough above the soil to escape the moisture, before joining up the other wire. The objection to this is the cost of the additional cable or underground wire.

My best success in defeating the wiles of the enemy in such cases has been achieved through the use of asphaltum. I claim nothing new for my method, unless it be in the quantity used. I first bare the wire several inches either side of the joint, after the splice is complete and clean off all moisture, acid, etc. I then paint the naked wire with hot asphaltum up to and beyond the insulation on the white wire and beyond where I intend wrapping over the lead. After two or three coats, I alternately wrap and paint, thoroughly insulating each wrap from the next, until the whole is well covered. In no case would I permit the wrapping to touch the lead or the white wire beyond the painted portion.

If this is done faithfully there will be no connection between the lead on one side and the white wire on the other, by which moisture will travel across, and if the joint is finally left in such a position that moisture accumulating on the lead by condensation will have to run up hill to reach the joint, and the line is kept clear of ground leaks, there will be, I fancy, little annoyance at that part of the line.

There is a traditional belief, as widespread as it is erroneous, that tape well rubbed down will stick forever. What a pity this were not the fact. The oily constituents of the insulation soon evaporate, and the tape peels off. A couple of inches of small wire will hold the last end of a piece of taping, if carried once around, and the ends are twisted together.

There is sometimes a fruitful source of trouble through imperfect contact, at the lamp binding posts. An imperfect contact, a loose screw, may result in an arc and serious injury to the lamp at that point. The constant vibration of the wire there tends to loosen the binding screw and, of course, to encourage trouble. Any form of hanger which shortens the loop of wire leading out to the lamp reduces the amount of this vibration and lessens the possibility of trouble at the binding-post. This loop may be successfully done away with on either permanent lamps or those which of necessity must be lowered or raised, and experience has shown in Chicago, that hangers which accomplish these results are far better and safer than the old form, not only on account of lessening the danger of a bad connection at the binding post, but on account of other good results which do not properly belong to the branch of electric lighting now under discussion.

Probably the very worst joints on a plant, all things considered, are those sometimes found in the dynamo room. Here under the eye and within reach of every employé of the company, the wires bear a certain resemblance to a lot of last year's spider webs, or the abandoned drying room of a country laundry. Call the attention of the party in charge to this condition of the wires and connections, and he invariably tells you that these are only temporary, though the dust of months has accumulated upon the joints ; the wrappings, where there are any, are flying in the air like piratical signals of distress, or hanging like a rag on a sore toe, and the wires are covered with black particles that tell of age and neglect. When I see one of these temporary wired dynamo rooms I dread to attack the circuit, for I feel quite sure I have an uphill task before me. It is usually an index to the condition of affairs all along the line. Such a dynamo room is in excellent keeping with a line filled with bad joints, ragged insulation, poorly attended lamps, dissatisfied consumers and unhappy stockholders. On the other hand, when I find the dynamo, wires and connections in proper form in the dynamo room, I feel that I shall at least be seconded in my efforts at reform, and usually am not mistaken.

Facts are usually capable of being borne out by figures. While the wires used in electric light work are perhaps less liable to become affected by imperfect connections, a comparatively lower resistance may result in serious trouble. In telegraph lines where iron wires are used, experience has shown that there may occasionally be found a joint of extremely high resistance, and, incidentally, I may mention that in the electrical department of the City of Chicago there are several of these specimens preserved.

The measurements of some of these are 2,000 2,800, 4,000, 5,000, and one measures 20,000 ohms. Each of these joints was taken from a working wire.

In conclusion, while primarily an electric light plant is dependent on its power and its insulation for economical results, no inferior factor in the question of success lies in the connections, whether these are permanent splices in the line wire, binding posts, screws at the lamps, or spring jack contacts at the switch-board. In each of these, and all other contacts which may occur, we must not forget that the law of Ohm is applicable.

PROTEST AGAINST THE ENFORCEMENT OF ELECTRICAL SUBWAYS.[1]

BY E. R. WEEKS.

It is a well-known fact that for conductors of electricity air is the best insulator and earth one of the poorest. How, then, are we to account for the objections made to aerial

1. Read before the National Electric Light Association, Detroit, Aug. 31, 1886.

lines, and the recent tendency to insist upon subway construction? Nine out of ten of the general public do not really care whether wires are overhead or not. If asked for an objection to so placing them, many would speak of the danger from lightning; some would characterize them as unsightly, while a more thoughtful class would note their hindrance to the fire department and the obstruction which poles offer to commerce. Some of these objections are valid, but whether all combined are strong enough to even offset those which may be urged against underground lines remains to be shown. As a matter of fact, aerial wires are a protection against lightning, instead of "making so much electricity in the air," as the common phrase runs. It is not in the city, but in the country, that most damage by lightning is done. Well constructed lines, with wires taut and parallel, or at proper angles, and with trim poles of an inconspicuous color, are not unsightly, but give to the streets an air of business. That wires do sometimes interfere with the work of the fire department, and that poles do offer some obstruction to commerce is freely admitted.

The numerous obstacles to subways may be classed as electrical, mechanical and popular—obstacles that hold against all wires, but most strongly offset those for telephone and lighting purposes. The efficiency of electrical service depends largely upon the insulation of the line and the steadiness and uninterrupted flow of the current. But underground wires, in addition to the increased and ever present danger of leakage, are seriously affected by induction and retardation, and no system of conduit has yet shown itself able to overcome all of these evils.

At a greater cost of construction, induction may be lessened; but no method yet devised has, in the least, reduced retardation, which is so vital a matter in telegraphic and telephonic communication.

The mechanical objections to underground lines are two-fold—those of construction and those of maintenance. The cost of such construction is so great that it is a question whether its enforcement would not only deter capital from entering the field, but would drive most of the present companies out of business. In Philadelphia, the city council, while passing ordinance after ordinance requiring private corporations to bury wires, exempted the city from doing likewise because it would bankrupt her. Wires for aerial arc lines cost about 1½ cents per foot, but those that are adapted to underground work range from 6 cents upward. Other items of construction are in about the same ratio. As has been said repeatedly, the cost of an electrical subway stands as a bar to its general use.

Consider the mere matter of space. Without tunneling, where shall we find a safe place for lines so easily affected as ours, under a street already criss-crossed by sewer, gas, water, and steam pipes at every few feet? If the space between these and the surface be utilized, conduits will be in greater danger from surface sewage, and liquid and gaseous leakage of all sorts; they will be subject to the constant jar of heavy traffic; and will be more seriously affected by changes of temperature. Such location, while permitting the most economic subway construction, would render the question of maintenance a vexing problem.

It may be said that these objections are urged in the interests of electric corporations only; that these corporations hold valuable franchises, and should be made to consider the welfare of the public; that if they be required by law to go below the surface, they will quickly devise methods for doing so. But in return for these franchises, electric corporations furnish accommodations that the public cannot well do without; and invention responds rather to the needs of the times, than to legislative demands.

However, there are other objections to subways that more nearly affect the public. I have designated them as "popular," though I believe few of the people have considered them.

Complaints are unceasing that gas, sewer and water construction and repair are a hindrance to commerce and pleasure, and render streets unsightly and dangerous. The frequent disturbance of city soil is a source of malarial disease of no mean importance. The necessary excavations for gas, water, sewer and steam connections are a nuisance of daily occurrence; but these connections are permanent. Not so with telephone and electric light work. It will probably be many years before a telephone or an electric lamp will be a fixture, passing from one tenant to the next as a matter of course. On the contrary, their location will be continually changing, and a frequent disturbance of malarial subsoil will result.

Again, much has been said of the danger to the public from aerial light wires. This danger is almost entirely imaginary. As such wires enter buildings from above, they are beyond the reach of ordinary traffic. But the leads to underground lines are subject to a wear and tear that will continually injure their insulation. These wires would therefore, not only be a constant menace to life; but, as they increase the danger of fire, would materially augment the rate of insurance.

The public is already clamoring for reduced rates for lighting and telephone service, but the greater cost of laying and maintaining underground lines would certainly prevent such reduction, if it did not largely increase present rates. In still another way will the public be incommoded by subways. Poles are now complained of as obstructions to commerce. But subways necessitate frequent man-holes and hand-holes in the pavement where wires must be drawn in and out. This is a slow process, and as extensions and alterations will always be required, there will, of course, be a constant obstruction to traffic at continually changing points.

Are not these objections, every one of which is real, sufficient to offset any and all that can be brought against aerial lines? But above and beyond these, is another that places the question of compelling the employment of subways upon the grounds of legality and equity. The whole matter of electrical subways is experimental. The New York subway commission reports: "The underground systems of Philadelphia, Washington and Chicago were personally examined by us during November, 1885, or rather such *embryo* systems as there exist." From Philadelphia comes the statement that that city "has arranged a *test* for 11,550 feet of underground wires to illustrate the practicability of such a system." Yet every one knows that the cities mentioned have the largest per cent of underground wires.

That electricity is an invaluable aid to commerce is now almost a truism. Yet few of those not immediately dependent upon it for the transaction of a great part of their business, realize that commerce would stagnate without its modern applications. Business men fully recognize that anything that interferes with the best electric service, equally affects the safety, rapidity and convenience of commerce, and, therefore, is not to be lightly held, and that only the most weighty objections to present methods are worthy to be considered. So fully is this realized, that all commissions appointed to inquire into the expediency of various new demands to be made of electric corporations have uniformly recommended caution and slow procedure, that the important duties of the telegraph, telephone and electric light companies be not interfered with.

There has been much newspaper talk as to the danger of aerial lines; and much has been said of the large extent of underground wires in various cities, and public attention has been so generally called to the subject that many cities have been led to suppose that there is an immediate necessity for burying all wires. The result is that a great deal of hasty legislation has been indulged in with very little consideration of the knottiness of the problem involved, and the great expense to which a most valuable industry would be put.

To quote again from the New York commission: "The

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difficulties which surround the successful solution of the underground wire problem in this city are of an extent and magnitude of which the public, as voiced in the general press, at least, have no adequate comprehension."

The adaptations of electricity are comparatively modern, electric lighting being but in its infancy. Almost everything in regard to the details of the work is experimental. Difficult as is the problem of a satisfactory method of burying telegraph wires it is greatly complicated for telephone and electric light lines. That any conduit will operate successfully for our business has not yet been shown. The percentage of wire now underground is small. In New York, where there is probably more than in all other American cities combined, it is about 6 per cent.

How, then, can the matter of subway construction be anything *but* experimental. That it is so is abundantly proved by the reports of all who have investigated the subject. The reports and contracts of the New York commission are full of clauses that show this conclusively. The most vital questions are left to be settled as the work progresses, because no one has the practical knowledge to settle them beforehand. There is no question that wires may be made to work underground. All electricians admit this; and many large corporations have made extensive experiments with a view to securing some feasible subway system. But, as yet, the question how to make them work *satisfactorily* and at a *reasonable cost* has not been solved.

In view of the existing state of subway experience, how can any legislation, looking to the forcing of all wires underground, be equitable to electric interests? The first investments for the electric lighting business are large; unexpected outlays are frequent; the life of the apparatus is unknown; and the improvements that are constantly being made necessitate many costly changes. All these facts protest against hasty legislation whose enforcement would practically prohibit many of the small beginnings so valuable to new industries.

There is another phase of the question that has as yet received little consideration. Electric companies have a large amount of costly apparatus that would be rendered useless by a wholesale enforcement of subways. Whether they can be compelled to bear this loss, in the present state of knowledge as to underground work, involves a legal point not yet settled. In fact the best legal advisers deny the right of a city to require any corporation to bear such loss, especially at the risk of unsatisfactory service. When some underground conduit has been devised that is practicable from electric, mechanic and economic standpoints, and that the people believe to be more desirable than overhead wires, there will be no need of legislation in the matter, as electric corporations will hasten to avail themselves of whatever promises best for their customers.

In view of the fact that subway lines have not yet been shown to render as reliable service as aerial ones; as the objections to them will be much greater than those now urged against the present method of running wires; and as the legal phase of the matter will involve cities in useless and expensive litigation, it seems wisest to hold the whole matter in abeyance, until the important tests about to be instituted in various localities, notably in New York, have resulted in the discovery of some underground plan that will give satisfactory service to both producer and consumer. This is the course of equity.

ABSTRACTS AND EXTRACTS.

A POWERFUL DYNAMO.

An exceptionally large and powerful dynamo, which has recently been laid down by Sir Hussey Vivian & Sons for the electrical purification of copper, is said to be one of the largest hitherto constructed for electrolytic purposes. It has an output of 50 volts, 1,000 ampères, at 400 revolutions. The weight of the entire machine is 5¼ tons; the magnet limbs are solid forgings, each weighing 22 cwt., and are shunt-wound only, each limb having 260 lbs. of copper wire. The armature is constructed of bars 0.338 square inch area, and has a resistance as low as 0.0016 ohm. The commercial efficiency of the machine is over 93 per cent. Mather and Platt are the makers. Severe tests having given most satisfactory results, it is reported that they have recently received an order from the same firm for a second precisely similar machine.—*Universal Engineer* (London).

ALUMINIUM.

That the day is near at hand when aluminium will play an important practical part in the arts is indicated by many concurrent signs just now, one of the greatest of which is that the largest dynamo in the world has been built for producing it, from designs of Mr. C. F. Brush, for the Cowles Electric Smelting and Aluminium Co., of Cleveland, Ohio. It converts about 400 h. p. into electricity, running at 430 revolutions per minute. Large works have likewise been erected near Bremen for producing aluminium by an analogous yet somewhat different electrical process, and the scientific journals of the world are now full of the subject, and generally speak in a most hopeful way of the outlook.

It does not yet satisfactorily appear that the price can be reasonably expected to be brought so low as to very seriously modify the coarser metallic processes which deal with large masses of metal, but the peculiar property which aluminium possesses of adding vastly to the strength and durability of the more common metals when admixed with them in only a small proportion will greatly facilitate its introduction on a large scale should the price fall even moderately low, while its light weight, ductility, non-corrosive qualities, low melting point, great strength and ease of casting or melting will speedily bring it into wide use for the finer metallic arts should its price become reasonable. For engineering instruments, for example, it would be an almost ideal material, and save the wear on the shoulders of many a tyro in field work. There is as yet, however, a plentiful lack of positive evidence as to what its price may fall to, but as the ore (common clay) is, next to silica, the most abundant of all materials and as power for producing the necessary strong electric current may be had at many points very cheaply, there certainly are interesting possibilities in the new processes. A bridge of aluminium, of any considerable span, would not need to weigh more than a fifth to a tenth or even a twentieth of an iron bridge of the same strength, so that a considerable price could be afforded for it, especially for making the alloys with larger quantities of iron and other metals which have properties closely resembling the pure metal.—*Railroad Gazette.*

LIGHTNING HOLES.

Professor Brun has published in the *Archives de Geneve* an interesting study on the so-called lightning holes to be found in the High Alps. He and other investigators have found them at heights of from 3,348 to 4,000 metres, or between 11,000 and 13,000 feet above the sea level. Usually they are found on summits. Sometimes the rocky mass, which has been vitrified in the passage of the electric fluid, presents the appearance of small scattered pearls, sometimes of a series of semi-spherical cavities, only a few millimetres in diameter. Sometimes there are vitrified rays going out from a central point to a distance of four or five inches. Sometimes a block detached from the mass appears as if bored through by a cannon ball, the hollowed passage being quite vitrified. The thickness of this vitrified coating or stratum never exceeds a millimetre, and is

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sometimes not more than a quarter of that depth. The varying colors which it presents depend on the qualities and composition of the rock. The same may be said as to its transparency. On the Rungfischhorn the glass thus formed by the lightning is black, owing to the quantity of actinolith which the rock contains. It is brown on La Ruinette, the rock consisting of feldspar mixed with gneiss containing chloride of iron. Under the microscope these lightning holes display many interior cavities, which must be attributed to the presence of water in the rock at the moment of melting by the electric discharge. This vitrified material has no influence on polarized light.

COMPARATIVE EFFECTS OF ELECTRIC AND GAS LIGHTING UPON TEMPERATURE AND ATMOSPHERE OF ROOMS.

An important investigation this year has been made by Dr. Breslauer, in Berlin. The question was to determine the difference, if any existed, between the effect of illumination by gas and that of electrical light on the air in a large crowded building (*Deutsch Med Zeit.*, Jan. 21, 1886). For this purpose the Royal Theatre, in Munich, was selected, and the experiments were made with that thoroughness with which they are usually undertaken by German scientists.

The air was examined in the parquet, the gallery and the centre of the latter, and observations were made while the house was full and when empty. The results were as follows: With electric light and with gas the increase of temperature noted from beginning to end of play was:

	Electrical light.	Gas.
In parquet	2.5	25.1
In gallery	8.1	26.1
Centre of gallery	9.3	26.7

The percentage of carbonic acid per mille was:

	Electrical light.	Gas.
In parquet	0.055	3,926
In gallery	0.870	3,151
Centre of gallery	1.178	4,353

Under the effect of gas the percentage of carbonic acid increased, therefore, above the limits of safety from 1.81 to 3.35 per mille. Many other observations concerning the percentage of watery vapor, etc., were also made; but we simply mention their result, together with the investigator's resumé of the whole.

1. The air with electrical illumination does not reach in a theatre the former high temperature, a fact especially of advantage to those frequenting the gallery.

2. The air remains purer; it contains far less carbonic acid, and almost no smoke particles.

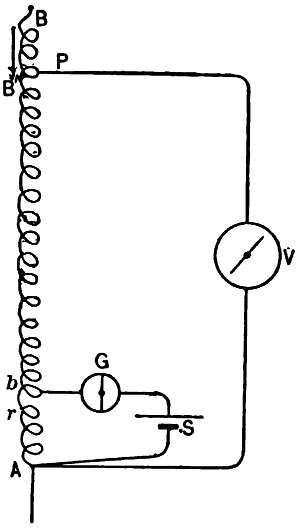
3. There is no longer so much moisture added to the air as used to be the case with illumination by gas, and the less the percentage of moisture in a crowded room the more agreeable will be the air to persons living in it, and the less favorable will be the conditions for the development and the propagation of pathogenic germs, especially if the moisture diminishes in the same ratio as the temperature sinks, always occurring under the effect of the electrical light.

4. The quality of the air has become a far more uniform one in all parts of the house, while with illumination by gas the air becomes the hotter, the more moist, and the more impure, the higher situated the seats are.

For hygienic purposes in the same theatre another alteration has been made, viz., the substitution of more opaque glass for the globes of the electric light. Though the illuminating power has diminished under its use from 20 to 25 per cent., the effect on the eyes is less injurious, as it produces a peculiar yellow light very agreeable to the eyes.—*Medical and Surgical Reporter.*

THE CALIBRATION OF VOLTMETERS.

A correspondent of the *Electrical Review*, of London, contributes the following simple method of calibrating a voltmeter:—A B is a resistance through which a current is flowing. S is a standard cell. One terminal of S is connected to A, the other through a galvanometer to a point, *b*, in A B. The resistance, A *b*, is such that no current flows through G. Let resistance, A $b = r$.



One terminal of the voltmeter (V) is connected to A, the other to a contact, P. Let P make contact with A, B at B[1]. Let resistance, A $B^1 = R$. Let the difference of potential between A and $B^1 = E$, between A and $b = e$. It is then evident that

$$\frac{E}{e} = \frac{R}{r} \text{ or } E = e\frac{R}{r}.$$

As no current flows through G, e must equal the E. M. F. of the standard cell. Therefore E, the difference of potential at the terminals of the voltmeter, is known. Note the deflection, and then move P to other points in A B.

It may be seen that it is only necessary to know the proportion $\frac{R}{r}$ and not their actual resistances. Volt.

LIGHTING BY PRIMARY BATTERIES.

During the past nine months a temporary primary battery installation has been in full work at the Guildhall School of Music. The installation consisted of 80 50-volt 10 c. p. incandescent lamps and one Brockie-Pell 2,000 c. p. arc lamp. The necessary current for the 50 incandescent lamps and the Brockie-Pell arc lamp in the practice room was supplied by 80 cells arranged 40 in series and two parallel. For the class rooms, 40 primary cells charged 26 E. P. S. accumulators. The accumulators were used to regulate the current for this section on account of the great variation in the number of lamps required at one time, thereby considerably increasing the cost of maintenance. The school and class hours ranged from 9 A. M. to 10 P. M., and in several rooms the light was constantly used, and during the foggy days the whole of the rooms were lighted during those hours. The Brockie-Pell arc lamp was in use eight hours during each week. The following statements give all necessary details:—

Greatest number of lamps running at one time	80
Number of Holmes-Burke cells	120
E. P. S. accumulators	28
Brockie-Pell arc lamp, 2,000 c. p.	1
Total number of lamp hours (incandescent)	43,200
Total number of hours run of arc lamps (35 weeks)	288
Cost of chemicals, including mercury	£46
Cost of zincs, less sale of old or waste ditto	£70

The above figures have been compiled from the books

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of the company which fitted up the installation, and the batteries used were the well-known Holmes-Burke type, manufactured by Messrs. Johnson & Phillips.—*Electrical Review* (London).

POSITIVE AND NEGATIVE ELECTRICITY.

Dr. Wachter, of Vienna, has recently communicated to the Academy of Science, in that city, a paper in which he attempts to prove that, contrary to the generally accepted belief, crediting positive and negative electricity with absolutely analogous properties differing only in sign, there are between them many points of diversity. He maintains that the properties of the two electricities are totally different, and these differences manifest themselves in regard to (1) equipotential surfaces, (2) direction of movement, (3) magnetic, (4) thermic, and (5) optic properties; also (6) in regard to the substances electrified. Dr. Wachter treats only of the first and second headings. He asserts that in conductors of great specific resistance the point where the potential has a mean value lies, not midway between the extreme ends of the conductor, but somewhat nearer the negative end. If equal quantities of positive and negative electricity accumulate respectively on two conductors of equal size, the potential, measured by means of an electrometer, has a greater value, irrespective of the sign, on the positive than on the negative conductor. The electric mill revolves in the direction of the flow of positive electricity, which proves that the movement of the molecules of air around a positive and negative point is different. The appearance of the discharge from such points is also different, indicating an inequality in the equipotential surfaces.

FREAKS OF A FLASH OF LIGHTNING.

During a severe thunderstorm which passed over central Norway last month, a remarkable example of the power of lightning was witnessed. In a field at Löten a fir tree, 80 feet in height, was struck by lightning some 12 feet from the ground, with the effect that the tree was cut in halves and the upper portion—about 60 feet in length—thrown a distance of several yards. The most curious part is, however, that the surface of the detached part is as smooth as if the tree had been sawn through, whilst that of the stump remaining in the ground is jagged, charred, and splintered to the root. The ground around the tree is furrowed in all directions, one furrow being several feet in width and depth, and extending for some 10 yards. A spruce tree close by shows a furrow an inch in width, running from a height of six feet down to the root.

THE OLDEST ELECTRIC LIGHT INSTALLATION IN EXISTENCE.

It is said that the Paris Hippodrome claims the honor of having been lit by electricity for the longest consecutive period on record. The installation dates back to the year 1877, when four "Serrin regulators" were first permanently installed. Each of these lamps was supplied from a separate Gramme dynamo in the manner then practiced. From time to time the number of arcs has been increased, but, strange to say, the primitive arrangements have not only been retained but positively extended, so that at the present time there are no less than *seventeen* "Serrin regulators," each with its separate and distinct Gramme machine! These arcs do not, however, by any means represent the entire installation. There are employed in addition 133 Jablochkoff candles and over 1,000 incandescents. The current for the Jablochkoffs is supplied by seven alternating Grammes, for which four exciters are employed. Three additional direct current Grammes supply a portion of the incandescents, and the remainder are provided for by two Edison machines, each supplying 400 8 c. p. lamps at 110 volts. The total number of dynamos is thus no less than thirty-three. All these machines are driven from one counter-shaft by cotton belting; the counter-shaft is driven in turn by two engines running at 180 revolutions. The machines are mounted on sliding frames, provided with screw adjustment.

ELECTROLYTIC SEPARATION OF METALS.

From solutions containing salts of various metals, the metals may be completely and successively separated in a state of purity by using currents of different strengths. The current first applied must be only sufficient to throw down the most readily precipitable metal, but not the next following. The more of this first metal is deposited the feebler becomes the current, and finally a galvanometer introduced into the circuit is no longer affected; a sign that now none of the metal precipitable by the existing electromotive power is present, but only such saline solutions as do not conduct the feeble current and consequently are not decomposed. If the negative electrode is charged and the electromotive power increased a second metal can be precipitated.—*Chemical News.*

A CHANGE IN THE ENGLISH PATENT LAW.

A change in the patent law, slight, but tending to relieve inventors of some trouble, was made by the last short parliament. Hitherto it was necessary in the case of unprotected inventions, shown at exhibitions, to give previous notice to the comptroller-general, lest the proprietary rights of the inventor should be thus forfeited. The new amending act relieves inventors from these conditions, but only on such terms as her majesty in council may deem fit. We suppose this refers to general notices, at the announcement of an intending exhibition.

STORAGE BATTERIES.

More than 25 years ago Charles Kirchoff devised an apparatus which was the forerunner of the present storage battery. He drew attention, amongst other things, in a patent issued to him in the United States in 1861, to the desirability of roughening the plates and perforating them so as to gain increased surface for action, and he recognized a great value for lead and its peroxide as the active materials, on account of their electric potential differences. Although the battery is described by Kirchoff as one in which platinum plates are used and lead plates are suggested, the platinum is only employed as a base upon which the peroxide of lead and lead are respectively deposited.

We learn from an exchange that M. Emile Raynier has succeeded, by very simple means, in overcoming the difficulty which sometimes arises from the swelling of the plates of accumulators during the process of charge. The plates constructed by M. Raynier are bent to and fro so as to present a succession of shelves or corrugations, and the active material is strongly compressed into the spaces thus provided. This particular feature is not new in itself, but the present improvement consists in bending the plates into the form of an arc of a cylinder whose axis is perpendicular to the direction of the corrugation. A battery of this construction has undergone a trial of some duration at Marly (Switzerland), and is said to have been perfectly successful.

AN IMPROVED WHEATSTONE'S RHEOSTAT.[1]

BY SIR WILLIAM THOMSON.

Wheatstone's rheostat was invented over forty years ago; but, though admirable in conception, and commonly

1. Read before the British Association, Sept. 7, 1886.

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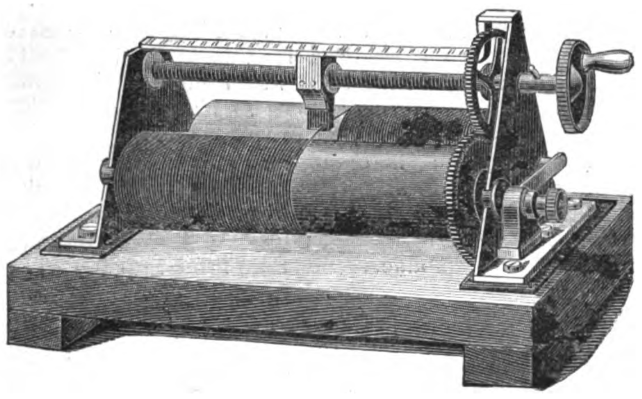
shown on the lecture table in illustrating and explaining the nature of electric resistance, it is scarcely if at all used in the laboratory. This is altogether owing to practical defects in the instruments as commonly constructed. The wire comes loose, the contacts are uncertain, and, the current being incessantly broken and made again, the galvanometer needle is perpetually swinging about instead of showing a continuously increasing or diminishing deflection as the resistance is wound out of the circuit or wound into it.

Modifications of the original instrument have been made from time to time; and a very important improvement was recently introduced by Mr. Jolin, of Bristol. In Jolin's rheostat, a toothed wheel, fixed on one of the two cylinders, gears into a toothed wheel on a shaft carrying the other cylinder, and a spring fixed to this shaft acts on the last-named cylinder, which surrounds it on the principle of the main-spring of a watch. By this arrangement the wire is kept tightly stretched, and the barrels can be turned both forwards and backwards by means of a handle attached to one of them; and the necessity of shifting the handle from one to the other when the motion is to be reversed is obviated.



In the improved rheostat the spiral groove in the non-conducting cylinder of previous instruments is dispensed with, and the wire is guided between the cylinders so as to be laid on them spirally by means of a traveling nut on a long screw. The screw is turned by the handle, and carries a toothed wheel, which gears into two toothed wheels, one of which turns one of the cylinders, and the other the aerial shaft of the other cylinder containing the watch spring. The guiding nut is also arranged to stop the motion of the screw shaft at each end of the range, and so prevent the possibility of overwinding. It also carries an index which moves along a graduated scale and counts the turns of the wire on the insulating cylinder.

In Jolin's rheostat the two cylinders are geared together, as already described. The two cylinders have usually been geared together directly, and turned in contrary directions, the wire passing from the upper side of one to the under side of the other. In the new instrument, as is seen in the diagram, the toothed wheels of the two cylinders are turned in the same direction by the wheel on the screw shaft, and the wire passes horizontally from the top of one cylinder to the top of the other.

The conducting cylinder and the wire are both of platinoid, a metallic alloy, having properties which make it specially suitable for the purpose. It has very high electric resistance, very small temperature variation of resistance, and it remains with its surface almost or altogether untarnished in the air. On account of the last named property the contact between the wire and the conducting cylinder is as perfect as can be desired; and continuity of action, which was a great difficulty in the old form of the instrument, is absolutely complete.

ON AN EXPERIMENT SHOWING THAT A DIVIDED ELECTRIC CURRENT MAY BE GREATER IN BOTH BRANCHES THAN IN THE MAIN.[1]

BY LORD RAYLEIGH.

This is, perhaps, a somewhat paradoxical title, but I thought by so describing the experiment I might, perhaps, bring out the real point involved in it. The question is, how do conductors in multiple arc, or in parallel, behave when subjected to alternating or periodic currents? The paradox is involved in the silent introduction of the idea that the currents are steady. If they are intermittent there is no reason for supposing that the current in the main is the arithmetical sum of the currents in the branches. It must be the algebraical sum under all circumstances. The question of the behavior of two conductors in parallel is a very easy one, if we suppose the currents to be steady. We have then the ordinary and familiar law of the division of the current between the two in proportion to their conductivities; but if the currents are alternating, and if the conductors placed in parallel have the property of self-induction, which they must have in some degree, and still more if they have a sensible mutual induction one upon the other, then the case becomes very much more complicated. In a paper I published a few months ago in the *Philosophical Magazine* I gave a general calculation of what the resultant resistance of the two conductors placed in parallel to alternating currents would be, and also what the resultant self-induction of the two would be. That is to say, I gave what would be the self-induction of any single conductor. In examining that closely I saw what appeared to be very curious things involved in it, and things which would be brought out supposing the two currents placed in parallel were composed of wires led side by side so as to travel very nearly along the same course, and I think I shall perhaps best explain what I have to say by limiting myself to that. Suppose that you have three wires led side by side together and made into a coil of a considerable number of convolutions, and suppose that you take two of those wires in series and combine them in such a fashion that the current will circulate in the same way round both of those, and take that as one of the conductors in parallel, and as the other conductor in parallel take the third wire, and then submit the system composed of those three wires, forming two conductors in parallel, to alternating currents, what will be the condition of the currents between the two conductors there, and how will they be related to the current in the main? Well, the theory shows that, when the rapidity of alternation is sufficiently great, the endeavor, as it were, is to cause the magnetic effect of the combined currents to be as small as possible at points which they influence, in fact, to neutralize as far as possible the magnetic effects, and that tendency more and more asserts itself as the rate of alternations increases, as the inductive coefficients increase, so that ultimately the distribution of currents comes to be independent almost completely of resistance, and to depend only upon the induction coefficients. And in this peculiar case, as you may see at once, the energy of the field of magnetization at various points not quite in the immediate neighborhood of the three wires, may be, in the distribution of the current, neutralized, because we have only to suppose that the current of the two wires joined in series is just half that, and in the opposite direction to that in the single wire in order to have at all points complete neutralization of effect; so that under the influence of rapid periodic currents this is the state of things. But, as you see, what is involved in that is this: The current in the one conductor, in the two wires placed in series, should be represented by $+1$, the current in the single wire by -2, and the current in the main $+1$, numerically less than one of the currents in the branches. This is, perhaps, the easiest form in which to make the experiment. It so happened that I

1. Paper read before the British Association, Sept. 3, 1886.

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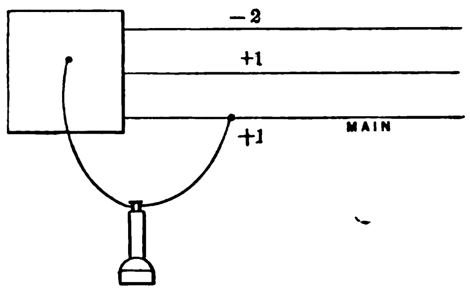
had a large coil triply wound, and I tried the experiment in the form in which I have related it. In order to estimate the currents in the three conductors I adopted the plan of having a piece of copper sheeting fastened to a board and three german-silver wires fastened to it. The current was tested by a process in which the telephone was used. Another wire was soldered to the copper sheeting and went to one pole of the telephone, and the german-silver wires were connected by touching at various points, so that if the currents had been equal in those three wires, the sounds produced by touching at the second telephone



terminal would have appeared equal. It was found at once that the current in one of the branches was very much stronger than the current in the other branch, and more than equal to that in the main. Knowing what one wants, it would perhaps not do to trust to one's self; still, by putting an assistant at the telephone, and by trying various places, it is possible to feel out the quality of the current so as to get something like a numerical estimate of it in this way. But I was not quite satisfied with that. I have said in my title, greater in both branches than in the main. I have arranged something else, but the principle is just the same. It involved iron, and it is most easily understood by having five wires instead of three. I combine them so that three are in series and two are in series; but the three in series are to be combined in parallel with the other two in series, so that in that way, in order to get neutralization of magnetic effect at a distance, it is necessary that the currents in the two branches in parallel must be in the opposite proportion taken negatively. The currents must be in the proportion of + 3 and — 2. That is the state of things; consequently both are numerically greater than the current in the main, which is + 1. I have verified it sufficiently to show that there is no difficulty whatever in so arranging the thing that the currents in both branches are decidedly greater than that in the main. Perhaps I might just say for the information of anybody who may wish to repeat the experiment, that it is a very easy one indeed, if you have a suitable coil to work upon. I used a scraping contact only, a battery and scraping contact to give the sound of the induction of the telephone. There was just a slightly perceptible difference in quality and degree when the sounds were caused to be as nearly equal as possible by varying the lengths of the wires, but not enough to interfere in any way with the experiment.

CORRESPONDENCE.

NEW YORK AND VICINITY.

Electric Railway Progress.—A Cross-town Line in Orange, N. J.—No More Free Franchises in Newark.—More Objections to Electric Lights in the Harbor.—The Hudson River Telephone Co. Invokes the Aid of the Law.—A New Automatic Delivery Company.—Subway Construction on Sixth Avenue.—No More Overhead Wires to be Built.

ELECTRIC railroading in this vicinity is soon to make a fresh start. Next month the Daft people propose to put a new and heavier motor on the Ninth avenue elevated road which it is believed will be fully equal to the work demanded, which proves to be from 125 to 140 h. p., instead of 55 to 60 as was originally calculated for. The Daft company are now fitting up two street railroads at Los Angeles, Cal., and expect soon to build another at Pittsburg, Pa.

Preparations are being made to build a cross-town electric railway at Orange, N. J., which promises to surpass in many respects anything of the kind in this country. Especial attention will be directed to the track which is to be of a superior character, and will be furnished by the Johnson Steel Street Railway Co., of Johnstown, Pa. The new road will be in a location where it is believed a very large traffic may be developed, passing all the stations of the railroads in Orange, also the hat factories employing 3,000 hands, and the Rosedale Cemetery. The granting of permission to use electricity as a motive power, has been laid over by the city council, until its merits can be investigated. The attempt of the Schuyler company to obtain a free franchise in Newark, has stirred up a hornet's nest in the city council, and efforts are being made to inaugurate a new policy by which the city may derive some benefit from its street privileges, instead of giving them away for the sake of encouraging competition.

The National Board of Steam Navigation, which met a few days ago at the Hoffman House, discussed the question of electric lights in New York harbor, against which many complaints are said to have been made by the pilots, who also ask that screens be placed in front of the lights at Hell Gate.

The Hudson River Telephone Co. recently brought suit against the Schuyler Electric Light Co., at Port Jervis, to enjoin the electric light company from erecting its poles and stringing its wires in such close proximity to the telephone wires and poles as to impair the usefulness of the latter. Judge Brown, of the supreme court, at Newburg, first granted a temporary injunction against the light company, and at a subsequent hearing, he made an order granting a modified injunction, which prevents the stringing of the electric light wires close to those of the telephone company pending the trial. The trial of the case is deemed to be important, as it is believed that it will determine the law applicable to two useful inventions.

The Automatic Delivery Co. has been organized with a capital of $500,000, for the manufacture and introduction of pneumatic machinery. Mr. E. S. Leaycraft is the manager of the new company, and a factory is now being equipped under his direction at 24 West street. Mr. Leaycraft has made several important improvements in this line of mechanism, and it is rapidly gaining favor for its convenience and reliability for store service, in conveying cash and merchandise.

Steady progress is being made in the construction of the general electrical subway on Sixth avenue. About ten blocks have been completed in three weeks, between Twenty-third and Thirty-third streets. The subway consists of two distinct lines of multitubular conduit, each containing 12 ducts, or 24 in a ll. They are laid on a bed of cement concrete, the same material being also used in filling in between the two lines, and the whole is enveloped in cemented brickwork, one layer of brick being used. It certainly makes a very substantial looking structure. The process of laying it is slow because of the time consumed in joining each duct in order to make them all continuous. Experience will doubtless suggest a better way of accomplishing this result, and as the work advances the men will become more skilled so that the progress now made is scarcely a criterion for the future.

The action of the Western Union Telegraph Co. in evading the provisions of the underground law, by stretching aerial cables on the elevated railway has brought about a decided change in the policy of the commission. The police authorities have received instructions to cause the arrest of any person engaged in making line repairs or stringing wire. The commission issues permits for necessary repairs but not for stretching new wire; consequently, it is expected that the lapse of time and growth of business will force the occupation of the subway wherever constructed in spite of the prejudice against doing so.

NEW YORK, Sept. 21st, 1886.

PHILADELPHIA.

Underground Wires.—Plans Submitted by the Bell Telephone Co. of Philadelphia.—Medical Electricity.

THE officials at the city electrical department are under the impression that before the end of the present year, a great many of the wires that are strung overhead will be placed underground. Steps looking to that end have already been taken by the Baltimore and Ohio, and the Postal Telegraph and Cable Co., which have now pending before councils a request that the right to lay conduits on certain streets be granted to them. Officials of both companies recently examined the maps of the electrical department of the city for the purpose of ascertaining the length and breadth of the streets which they will use, in order to determine what amount of conduits will be required. The Baltimore and Ohio company will possibly use one of the main streets, from Twenty-fourth street to the Delaware river, while the Postal Telegraph and Cable Co. will use another street, from Third to Fifty-second street. The company has been using the wires of the Bankers

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and Merchants' line, but wants to establish an independent underground service by the first of the year. Both lines run over the housetops, and if they go underground it will not decrease the number of poles on the street. According to the new ordinance they are required to file plans and specifications at the office of the highway commissioners. These are now being prepared, and the matter will soon come up for action.

Early in the week the highway supervisors convened in special session to consider ways and means for placing the telephone and other electric wires underground. Chief engineer and surveyor Smedley, president Bentley, and chief of construction McAleer, of the Bell Telephone Co., were in attendance. The latter submitted profiles and plans for conduits to carry the Bell telephone lines underground; which were inspected by the committee and briefly discussed. Accompanying the drawings was the following:

THE BELL TELEPHONE COMPANY OF PHILADELPHIA.

PHILADELPHIA, September 11, 1886.

Board of Supervisors Highway Department of the City of Philadelphia:

Gentlemen: We present herewith for your consideration and approval a plan, with detailed diagrams (made by Mr. Cranmer), for placing conduits and electric wires under certain streets named therein, between Vine street and South street, the Delaware river and Schuylkill river, and on Market street to Fortieth street, West Philadelphia. This system will enable us to reach each building within the boundaries named direct from the terminal or distributing poles. To reach these poles we propose to lay lateral cables north and south of the main conduit on Chestnut street on every other street, as Front, Third, Fifth and Seventh, branching from these lateral cables again and reaching the terminal poles by the most direct small street, where such is possible.

For the main conduits we desire to use cedar logs six (6) inches square, with a hole bored in the centre, of three (3) inches, for drawing the cable through.

The man-holes to be placed at the junction of the main with the lateral conduits and to consist simply of a wooden structure, with a covering of same material near the upper surface of the conduit, and filled in with earth and paved the same as other portions of the street.

Very respectfully,

SAM. M. PLUSH, General Manager.

President Bentley assured the committee that his company had used all possible expedition in having plans prepared, so that councils might act advisedly upon their proposition, and it was now ready to go ahead with the work of placing its wires underground as soon as it had the proper authority to begin operations. He presented an ordinance giving the Bell Telephone Co. such authority, with certain restrictions and limitations, and asked its early consideration by the committee. It was important, he urged, that there should be as little delay as possible, as the company desired to do considerable work before winter set in.

Chief engineer Smedley said the committee could not act until it had a digest of the proposed ordinance and considered it in all its bearings. The committee also thought it would be better to give all companies interested a hearing before taking any action, and adjourned until Wednesday afternoon, when consideration of this important matter will be resumed. All companies having wires strung overhead in the city will be invited to send representatives to this meeting.

President Bentley estimates that it will cost the Bell Telephone Co. over $450,000 to place its wires underground according to the plan submitted to the committee yesterday.

On the evening of September 8th, Dr. C. R. Norton read an interesting paper on the use of electricity in rheumatic diseases, at the meeting of the Homœopathic County Medical Society. His paper consisted of a history of several cases that had come under his own observation. A young man came to him suffering from a rheumatic inflammation of the ankle joint. A galvanic current was passed through the joint and after a few applications the patient became very much relieved. A young woman suffering in the same way was treated to 28 applications, and the joint improved so much that from being hardly able to limp she was able to walk with only a slight halt.

Another case was that of a woman 50 years of age, who suffered from a rheumatic neuralgic pain in the right shoulder and arm. The arm was almost helpless. A current of galvanic electricity just strong enough to be felt was passed through the parts, one pole being placed on the cervical vertebræ and the other passed along the arm. It was an obstinate case, but the trouble was much relieved, and the arm, instead of growing steadily worse, is of more use than before.

Much good was also effected in a case of diphtheretic paralysis. The patient's feet were put in water and galvanism applied, one pole being placed in the water and the other on the back or neck. A great improvement was noticed. The treatment was not so successful in cases of sciatica, although a change for the better was noted in some instances. When tried on an old man afflicted with tic-douloureux, it failed completely, but it was supposed that the age of the patient operated against its success. In neuralgic affections it generally relieved the patient, and the improvement was nearly always permanent. It was also useful in many surgical operations.

The paper was generally discussed, but the remarks were principally on the kind of battery to be employed, all admitting the efficacy of galvanism as a remedial agent.

PHILADELPHIA, September 16th, 1886.

BOSTON.

Convention of the National Association of Fire Engineers.—Output of Telephones by the American Bell Telephone Co.—Electric Light and Fire Alarm at Malden.—Dividends of Telephone Companies.—Electric Light at Salem.—Electric Railways.—The Fire Department of Boston.—Hydraulic Engine Trial.—Underground Telephone Wires.

THE fourteenth annual convention of the National Association of Fire Engineers opened its sessions at Providence, R. I., on August 24, at 12 o'clock noon in Free Mason's Hall. In the evening the session was continued, and several important addresses were read. The first was by Osborne Howes, Jr., secretary of the Boston Board of Fire Underwriters. The paper was a description of experiments carried on by that board for the reduction of the number of fires and fire losses. The city of Boston was divided into districts, each containing as many risks as could be examined by a single inspector in three months. Each inspector is required to report in answer to a series of questions furnished him, twenty-five in number, in regard to the heating apparatus, lights, fire doors, attics and condition of the buildings in his district. When defects are found the owners and occupants are notified and asked to remedy them. This has resulted in greatly improved care of the buildings by occupants, the apparent effect of which, thus far, has been to produce a diminution in the number of fires, and in the aggregate fire loss to the amount of $200,000. The speaker thought that the same system of inspection by local paid fire departments was not practicable, since the fear of having to pay more in insurance is what induces many people to make the changes requested by the board of underwriters.

The next paper was upon the dangers of electric light wires, and advocating the underground system, by Mr. J. P. Barrett, superintendent of the Chicago fire alarm. He prefaced his remarks by explaining the principles of electric conductors and the results of accidental ground connections in setting fires and in interrupting the action of the fire alarm apparatus, the great danger of which was emphasized. With a wire of suitable conductivity, well insulated and protected from mechanical injury, placed underground there is far greater safety and certainty than the overhead lines can give. Outside of first cost, everything is in favor of underground wires. Up to July 1, the city of Chicago and various companies interested had taken down 608 poles and removed 917 miles of aerial wires, and had made a mighty stride in favor of the underground system. In 1877 operations were begun by laying 840 feet of iron pipe, treated inside with tar, and through this drawing two kerite wires. The agitation was kept up, and in 1881, a law was passed compelling all corporations and individuals controlling wires in Chicago to place them underground. Chicago had now underground systems of several kinds, iron pipe, wooden boxes, filled, some with asphaltum and others with cement, etc. In the business part of the city the problem of earthing was as difficult a one as the underground system can present. By using a duct in the conduit and utilizing the space beneath the sidewalks, between the area wall and the building line, the problem was solved in a manner highly satisfactory. The wires placed in the iron pipe in 1877 are giving as good service to-day as the day they were planted.

At South Framingham, on the 30th of August, an agent of an electric cable railway concern appeared before the board for the purpose of presenting the plan of connecting South Framingham and Framingham Centre, distant two miles, with his railway. On the 7th of September, the court room was crowded at the hearing on the petition of the Suspension Transportation Company for permission to build an electric cable road to carry passengers and parcels between South Framingham and Framingham. Chairman Adams, of the board of selectmen, said the selectmen were ready to hear anything for or against the scheme. A. D. Chandler, solicitor of the company, said he would answer any questions any one might ask. Rev. L. R. Eastman, Jr., wanted to know whether the patents controlled by the company covered surface cable roads? Mr. Chandler replied that they did not. David Fisk wanted to know how high from the ground the cars would run? Mr. Chandler said they would be run at any height necessary. R. L. Day proposed the appointment of a committee to examine the system where it was in practical operation. E. W. Chandler said the citizens would not be asked to take any risk in the matter. W. C. Wight said that inasmuch as no plans or surveys had been submitted, and as a new petition is to be presented, and that the probability was that a surface railroad company would also present plans and estimates, for horse car service, he would move that the meeting be dissolved. This was unanimously carried.

The statement of output of telephones by the American Bell company for the month ended August 20, compared with the output for the corresponding period of last year, is herewith given. The large number of returned instruments is explained in large part by the action of the city council of Evansville, Ind., in causing the temporary suspension of all exchange service by cutting the wires and poles of the telephone company, as a result

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of the application of the "Indiana law," necessitating the return of all the instruments to the Bell company.

August.	1886.	1885.	Increase.
Gross Output	3,047	2,009	1,038
Instruments returned	2.763	2,553	210
Net Output	284	*544	828
Dec. 21 to Aug. 20.			
Gross Output	27,961	22,204	5,757
Instruments returned	13,407	17,350	†3,943
Net Output	14,554	4,854	9,700

Comparison with previous months—

	Aug.	July.	June.	May.	April.	March.
Gross	3,047	3,279	4,581	4,551	3,677	2,819
Returned	2,763	1,382	1,216	1,359	2,499	1,232
Net	284	1,897	3,365	3,196	1,178	1,587

* Net Loss. † Decrease.

The Malden aldermen have authorized the committee on street lights to contract with the electric light company for six additional lights. Although a new enterprise, the electric light is very popular in Malden. The fire alarm is also being extended in Malden, new bells, etc., are being purchased.

The Bell Telephone Company have declared a quarterly dividend of 3 per cent.

It is said the New England Telephone Company will declare a dividend of 1 per cent.

The directors of the Erie Telephone Company do not deem it advisable to increase the present rate of dividend, although the company is earning sufficient to pay more. The present management say they fear no trouble from the Bell company, in regard to renewal of the contract of the Cleveland division in Oct. 1889, or of the southwestern division in April 1891. Mexican and Tropical and the other exotic telephone companies, will wait until the earthquakes subside before paying dividends.

In Salem the work of putting in the electric light plant progresses; the 100 poles contracted for will be in place by October 15th. Salem has adopted the Pearce and Jones system of fire alarm, and the contracts will be made at once.

Telephone rumors have been abundant during the last month, especially those referring to the Gray inventions. It may be possible that some of Gray's old applications filed during the years 1875–'76–'77 and 1878 which have been in interference in the patent office, ever since, may be furbished up and allowed to issue. In such a case, it would seem that any such issued patent would be the property of the Western Union Telegraph Co.

It has been reported that at a meeting of the directors of the Metropolitan Horse Railroad it was decided to introduce either electricity or cables as the motive power; that president Richards appointed a committee to thoroughly investigate the relative merits of both systems, and whichever proves in the opinion of the directors to be the most reliable and best in all respects will be adopted. Something will have to done before many months to relieve the streets of Boston from the blockades occasioned by horse cars; every innovation meets with the resistance of the conservative Bostonian, and of the street railroads, but something will break before long.

The *Enos* people are building an electric railway at Winthrop. There are rumors of the organization of a strongly capitalized electric railway company in Boston.

I have collected a few notes on the Boston fire department which are interesting. The organization of the department consists of a board of three commissioners, a chief engineer, a superintendent of fire alarms, 13 engineers, and officers and other members, including telegraph operators, to the number of 689 men. The board of fire commissioners consists of three members. One member is appointed annually, for a term of three years, from the first Monday in May each year. The nomination is made by the mayor, subject to confirmation by the board of aldermen.

FORCE AND PAY ROLL.

1	Chief engineer	$3,000	per annum.
1	Asst. " and inspector of hose and harness	2,000	"
9	" "	1,000	"
3	Assistant engineers on call	300	"
1	Superintendent of apparatus repairs	1,600	"
1	Clerk	1,300	"
1	"	1,200	"
1	"	1,400	"
1	Detailed man as clerk, apparatus repair-shop	720	"
1	Veterinary surgeon	1,600	"

PERMANENT FORCE.

44	Foremen	at the rate of	$1,250	per annum.
16	Assistant foremen	" "	3.00	per diem.
32	Engine men	" "	1,200	per annum.
31	Assistant engine men	" "	1,100	"
57	Hose and ladder men	" "	1,000	"
135	" "	" "	3.00	per diem.
13	Permanent substitutes	at the rate of	$900	per annum.
1	Chief's driver	" "	720	"
1	Hostler	" "	720	"
2	Watchmen	" "	800	"

By an order of the city council, permanent hose men and ladder men receive at the rate of $1,000 per annum, for the first two years of service, and $3.00 per day thereafter.

CALL FORCE.

9	Foremen	at	$300	per annum.
1	Foreman	"	200	"
189	Hose and ladder men	"	225	"
54	" "	"	175	"
20	" "	"	150	"
29	" "	"	100	"

FIRE-ALARM TELEGRAPH.

1	Superintendent	$2,800	per annum.
1	Assistant superintendent	4.75	per day.
1	Foreman of construction	4.50	"
3	Operators	4.00	"
1	Repairer	4.00	"
1	"	3.75	"
1	Assistant repairer	3.25	"
1	" "	3.00	"
3	" "	2.75	"
2	Laborers	2.25	"
1	Battery man	$600	per annum.

The city is divided into ten fire districts, each district being in charge of an assistant engineer.

Considerable new construction and repair work has been done by the fire-alarm department; new circuits have been run, gong circuits have been completed, by which the box-gong service, heretofore given to the department houses in the city proper, has been extended to the houses in South Boston, Charlestown and Roxbury. The telephone service has been extended to the house of chief engineer Webber, chemical engine 3, and the new repair shop, and one telephone discontinued, making 60 stations now connected with headquarters.

A new seven-wired 300 feet cable has been laid at Mt. Washington avenue bridge. Fourteen new signal boxes and four keyless doors have been added to the service, and thirty keyless doors of new pattern substituted for old style within the year.

Changes have been made in the construction of the circuits in Charlestown, by removing the wires from house-top structures to poles. Commodious apartments for construction and repair work and storage of stock and tools have been fitted up in the building adjoining the fire department apparatus repair shop, supplying a long felt want in this department.

Stock has been used as follows:—

72 miles No. 9 iron wire; 9,150 feet kerite wire; 200 lbs. cotton insulated wire; 9,400 feet lumber; 3,500 insulators; 4,300 insulator bolts; 2,100 lag screws; 300 feet 7-wired armored cable; 157 poles.

Fourteen relays and twelve galvanometers have been added to the apparatus at headquarters to provide for the extension of the gong service, referred to above, as well as for future work.

An instrument has been lately introduced, the use of which greatly facilitates the recording of the time of alarms correctly. It is called the Automatic Time Stamp, and is so placed by the register that the paper bearing the record of the number of the box from which an alarm may be given passes through it, and receives an impression from the stamp showing not only the day of the month but the hour and minute whenever it is used.

A trial of the Orne battery has been made with satisfactory results. It is especially adapted for open-circuit work, and in point of strength and cleanliness has thus far proved to be superior to any acid battery heretofore used. It is intended to supply the telephones with it as occasion arises for a renewal of their battery service.

Total number of actual fires, 621; confined to one building, 515; extended to others, 18; wharves, vessels, grass, etc., 88.

There have been 785 fires and alarms, and 49 different causes are assigned therefor:

Our old friend "unknown" caused 122; the little match game scored, 87; the kerosene product is responsible for 69; and electric light wires are let off with 4.

There has been considerable newspaper discussion relative to the ringing of bells all over the city when a fire alarm is turned in, and the department say, that so long as the service consists in part of "call men," just so long the bells will ring. There are, however, a large number of "still" alarms, every week.

The Shaw Hydraulic Machine Company, by permission of the Hyde Park Water Company, gave an exhibition on the 14th inst, at the pumping station at Hyde Park of a small hydraulic engine and its applicability in producing electric light. Four incandescent 16 c. p. lights were run with a consumption of between 600 to 700 gallons of water per hour. Quite a number of citizens present expressed satisfaction with this means of illuminating their homes or places of business.

The New England Telephone Co. have secured rights from

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the city of Boston to lay underground conduits from the central exchange on Pearl street, to a sub-office on Tremont street; and are now laying a conduit through Berkley street, near the Tremont street sub-office, to extend to the Back Bay district. The conduit is of creosoted plank, divided into six ducts for drawing in cables.

BOSTON, Sept. 16, 1886.

CHICAGO.

The Detroit Electric Light Convention.—The Wire Gauge Question.—Electric Railways.

THE convention of electric light people at Detroit, which spanned the breach between summer and autumn, was a rare opportunity for the discussion of two or three mooted points in the convention, and some outside the sound of the chairman's gavel, in the open air; among these, the question of tower lighting.

Of all who were present at the convention, it is very doubtful if more than fifteen per cent. could have been depended upon to advocate the claims of tower lighting, when the long procession of coaches left the Russell House on a tour of inspection, Tuesday evening, at the invitation of W. W. Leggett, Esq., of the local Brush company of Detroit. The expression of opinion was loud and quite general from the time of the invitation up to the "all aboard" command, that Mr. Leggett was doing a foolish thing—albeit a very generous one—to ask a lot of sensible people to go out and search for light through an almost continuous grove of trees, when the source of luminosity was an hundred or two feet up in the air! It was preposterous.

We all went, however. We enjoyed it, too, despite the unwelcome and uninvited presence of a dyspeptic reporter for the *Journal*, who, under pretence of a desire to learn something, forced himself—both mentally and physically—upon one carriage load in which were two representatives of the ELECTRICIAN AND ELECTRICAL ENGINEER.

It is evidently a great thing to be a reporter for an evening paper in Detroit. We tried to make up our minds—we, the party of four—that this was so, but——oh! yes, about the tower lights. Well, the Brush company, of Detroit, lights an area of about 21 square miles from a single station. The lights, except in occasional instances, are placed in groups on towers one hundred and fifty feet high—a few even one hundred and seventy-five feet above ground. The groups are mostly of four, occasionally one of six lamps of—so-called—2000 c. p. The towers are scattered with due regard to the best effect, and stand upon one leg—a post—the equilibrium being maintained by stay wires. The daring individual who trims the lamps, raises himself to their level by an elevator of one man power, within the structure. In case of necessity he can use a series of steps which go up one angle of the tower. This is only intended for a case of emergency, when some funny man has fastened the hoisting apparatus while the trimmer is at work, or some equally trivial occasion when the elevator won't move.

Detroit is decidedly a forest city. While Cleveland has its Euclid avenue, Buffalo its Delaware, and many another avenue well lined with grand old elms and maples, Detroit seems to have been doing little else for the past half century by way of pastime, but to grow trees.

There are places in the city where a double row of beautiful forest monarchs reach out their joyous arms and kiss above the roadway below; and this too for half a block at a stretch. At the entrance to one of these high-arched primeval temples we would suddenly come pat upon an arc light on a telegraph pole, its daring brigand-like flicker and stare nearly blinding every one, while everywhere apart from these uncanny spots, the diffused rays of a portion of the 576 tower lights, either too high above us to be unpleasant, or too far away to be dazzling, cast in every direction a gentle, soft, moonlight sort of illumination which was a complete and glorious surprise to all. The drive was a "personally conducted" excursion—Mr. Leggett playing the part of Cook & Son, and an admirable guide he made; for the darkest alleys and most shaded spots were selected to make his victory over our prejudices the more complete. To use a base-ball idiom, "the Detroit's won the game."

The wire gauge question is very amusing to one who stands on an elevation outside the arena and looks on. In the wire business now, we have hardly enough gauges to accomplish the only end which seems likely to be reached in the long run. It has got to the point now that when a man says "a No. 6," he is asked if he means Birmingham or B. and S., or something else, and every fellow doesn't know; that is the man who dresses in a broad belt with connector and plier pockets in it, and wears spurs that would make a Mexican green with envy.

By and by, "when we have about three gauges more," as the boys on furlough used to say during the war, we'll all come to the plan now in vogue all over Europe, save in the British Islands, and use the decimal parts of a metre, dropping all this British gauge business, which is on a par with so much other anglophobia, because "it's English you know." If we must have a gauge, let us take one that is at the same time French, Belgian, German, Italian, Russian—everything on the Continent but English.

The hospitality of the convention's entertainers was the theme of many a little knot of delegates in the intervals of discussions and the resting places between meals and—naps. There was no regular sleeping. The Russell House offered facilities in the way of beds and furnished keys to the doors, but there was an *open sesame* sort of power to the rap of the night watch in its perambulations, which rendered nugatory all bars, defied all bolts, and banished sleep and anger from the most weary.

In vain were the legends "office hours from one to three A. M.," "closed by the Sheriff," "No telegrams received after three thirty A. M." "I have moved," and the like placed upon the doors. "When the horn blew the sleepers arose," as some old writer has it, "and friends met friends with fond embraces, as friends—not foes."

Everything at Detroit was pleasant, profitable and gratifying. The papers were all of a class at once dignified yet unstilted, and showed the writers had well digested their subjects.

Several of the delegates took part of a day off, and visited the two electrical railways. By a misunderstanding, in an attempt to reach the Van Depoele railway the party went north, and came upon the unfinished road of the Detroit Electrical Works Company. This being in no condition to furnish transportation for the crowd, steps were retraced to the Russell House, and a new start made to the westward. Mr. Van Depoele had but just got the road into operation, and was running at irregular intervals, over a track one and one-quarter miles, with perfectly satisfactory results. The time made varied from four to four and a half minutes over the route. The train consisted of one ordinary horse car, and the motor car, which had been made from a car similar to the first. There was no lack of passengers, and no end of boys who tried to catch on. One trip was made in a much longer time than the average. Some ten or fifteen cows were on their way up to town to be milked and spend the night, and they could not understand how a car could run without a horse. Either the cows or passengers came near being badly "collided." Just before we found out which it would be, Charley Van Depoele shut off the current, and stopped the sudden tide of emigration from the motor into the passenger car. We lost time, but we saved—well, the cows or the folks, and as before remarked, we never will know which.

Next morning a lot of the members crossed the river to Windsor, and made several trips over that road, which is also a Van Depoele, and were well pleased with the system. One of the party who was late to arrive no sooner put one foot on the motor car than it left the track and started to climb a telegraph pole. An axle had broken. It was afterward rumored that the Jonah of the occasion was a believer in the possibility of lighting large installations with thermal batteries, and that this was too much for even a Van Depoele motor.

Those who were at Detroit will have none but pleasant recollections of the convention, the city, and the hospitable people who so well entertained and made us happy.

CHICAGO, September 15, 1886.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICIAN AND ELECTRICAL ENGINEER, 115 *Nassau Street, New York city.*

A SHORT-SIGHTED POLICY.

[59]—The action of electric light companies throughout the United States in adopting and using almost universally, a conductor that is uninsulated, is a step in the wrong direction that is difficult to reconcile with economical management. I say uninsulated conductor because that is practically what it is. The copper conductor is *covered* but not *insulated.*

The electric light companies are stringing over housetops and on poles throughout almost every city of 10,000 inhabitants in the United States, what is called "underwriters' approved wire." The name is supposed to be a first-class recommendation for the wire and serves as a cloak to cover a multitude of evils. The board of underwriters probably approved the use of this wire *throughout buildings* but they certainly never recommended or approved its use *outdoors* where it would be subject to moisture.

Careful experiments made by immersing 12 inches of this wire in a 6x8 glass jar filled with water, the ends of the wire

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extending above the jar so that the water would come in contact with the covering only, shows the following insulating properties:

After 1 minute's time....resistance, 115,000 ohms;
After 3 minutes' time....resistance, 4,170 ohms;
After 5 minutes' time....resistance, 1,770 ohms;
After 1 hour's time....resistance, 280 ohms;

100 cells of battery were used in making the tests, one pole of the battery being connected with the water in the jar; the other pole with the copper conductor.

Experience has proven beyond the possibility of a doubt that it is just as fatal to life to come in contact with the covering of the wire when it is wet, as it would be to come in contact with the naked copper wire. Two men have recently lost their lives in this city by accidentally touching the covering of an electric light wire when it was damp. The Western Union Telegraph office, and the jewelry store of Duhme & Co., in this city, were set on fire at about five o'clock in the evening during a light rain by some one throwing a short piece of wire from a building in such a manner as to make a contact between an electric light wire and a telegraph wire. The electric light company has compromised with the widows of the two men who lost their lives, and the probabilities are that they paid out a sum sufficient to replace all their present wires with well insulated ones. It has not taken them long to see the folly of using uninsulated wires and they are now renewing the plant with insulated wire. Notwithstanding the fact that the use of uninsulated or "underwriter's wire" has within the past two years caused the death of at least 100 persons and destroyed property to the amount of over one-half million dollars in the United States, yet we see the new companies all over the country following in the footsteps of the older ones, and subjecting themselves to heavy damages that may result from loss of life and property.

To make matters worse, they attempt to construct their lines parallel with and on the same side of streets with telegraph and telephone wires, and thus bring about litigation that costs them, to commence with, four-fold more than it would have cost to string well insulated wire.

The press informs us that new suits are being brought almost daily, and the electric light companies are apparently so blind to their own interests as to suppose that the telegraph and telephone companies desire only to embarrass them and have no real grievance, when the fact is that these parallel lines are a menace to the property of all companies having wires on the same streets. It is apparent to any one that where two sets of wires are strung parallel, one above or below the other, that they will come in contact with each other during storms or fires; in fact it is impossible to prevent frequent contacts. Whenever there is a contact, it means a fired telegraph office or telephone exchange, possibly death to some employé. Every residence or business block that has a wire of any kind connected with it is liable to be set on fire at any moment by a contact between the various wires which form such a network throughout every city. Telephone employés inform us that it is a very common thing now to find telephones that have been set on fire at night and burned up, the charred remains having fallen to the floor.

I know that the electric light experts will go on the stand and swear that one "ground" or "cross" will not cause the electric light current to be deflected from its regular channel *when the balance of the circuit is insulated*, and they tell the truth, but not the whole truth. The trouble is *the balance of the circuit is never insulated.* It is very well known among the electric light people that the insulation of their circuits is uniformly low, and when one good "ground" is established by the crossing of wires, the intense electric light current immediately establishes a second "ground" and in this way the currents leave their proper channel.

The standard resistance of a mile of electric light insulation is or should be 1,000,000 ohms, while in actual practice it runs below 100,000 ohms, or less than one-tenth of the standard.

When persons have accidentally taken hold of electric light wires we know they have been instantaneously converted into angels, and all the figures and theories produced cannot satisfy the public that the current will not leave the conductor, or that it is not dangerous. Mr. Robbins, the superintendent of the Dayton (Ohio) Electric Light Co., seems to have had some faith in the theories advocated by his people, and when a lamp fell in the street he tried to pick it up by the insulated wire, but the theories all failed, and he is numbered among the victims.

It does seem that enough lives have been sacrificed, enough property destroyed and money lost to bring the stockholders of electric light companies to their senses; but still the ruinous policy is followed, and there will probably be no relief or change until the various states take up the subject and enact suitable legislation, and not only enact it, but enforce it.

Ohio has placed upon the statute books a law requiring all electric light companies using dangerous currents, to use conductors having a *waterproof insulation*, but no attention is paid to it. The "underwriter's wire," or more appropriately the "undertaker's wire," is still used with but one or two exceptions, and every company disregarding the law will run against a snag when it is brought into court in damage suits.

The currents used for "arc" lighting are all dangerous. The potential of the different systems varies from 30 to 50 volts per lamp, and as it requires a potential of less than 400 voltsto produce death, no company could operate a system of over 13 lamps without using a dangerous current. Few, if any, systems use a current for "arc" lighting of less than 2,500 volts, so they are all practically six (6) times more powerful than is necessary to produce death.

As the companies do not seem to fully understand the principle of self-preservation, it is to be hoped that the legislatures will take up the subject this winter, and enact laws necessary to protect the electric light companies from bankruptcy, and which will prevent the unnatural and unfortunate boom in the undertaker's business, which has recently sprung up, in consequence of the short-sighted policy of electric light companies.

I. N. MILLER.

CINCINNATI, September, 2d, 1886.

ELECTRICAL NEWS AND NOTES.

THE NATIONAL ELECTRIC LIGHT ASSOCIATION.

SEMI-ANNUAL MEETING.

The fourth meeting of the National Electric Light Association which assembled at Detroit, on August 31st, was a fairly representative body, there being present at its opening 77 members and associates. Perhaps half of this number arrived on the preceding day, including one delegation of 20 from the east. Others arrived and some departed before the final adjournment, thus keeping up a good average attendance throughout, excepting at one afternoon session when the counter attraction of a base ball game proved sufficient to draw away a score of gentlemen having sporting proclivities. Most of the members were quartered at the Russell House, while the meeting was held at the Council Chamber of the City Hall directly opposite. Eastern people who have heard considerable regarding the ample hotel accommodations in large western cities will doubtless be surprised to learn that this electrical visitation overwhelmed the Russell House, and visitors were subjected to much inconvenience by the crowding which they were compelled to endure in order that all might be accommodated. In addition to the discomforts which were endured, the highest schedule rates were exacted, leading to no small amount of grumbling. This was the only drawback to the occasion, and as every one was delighted with the city in every other respect, and thoroughly appreciated the attentions bestowed upon them by Messrs. Leggett and Fitzgerald, this particular annoyance was all the more conspicuous.

President J. F. Morrison has been so important a factor in the growth of the association, and the interest taken in its meetings, that considerable disappointment was shown because of his compulsory absence by reason of the sudden illness of his wife who started west with him but was taken sick on the road. Vice-president E. R. Weeks called the meeting to order at noon on August 31st, and occupied the chair during the various sessions, despatching business with commendable skill, and bringing about a final adjournment at the very seasonable hour of 2 o'clock on Thursday, September 2nd.

One of the most important features of this meeting was the opportunity afforded for a personal inspection of the merits of the tower system of electric lighting, which is here used to a very large extent, covering 21 square miles of territory, lighted by 122 towers, and 78 pole lamps. Most of the towers are 150 feet in height, supporting four 2,000 c. p. lamps, there being four of 175 feet with six lamps. Eleven carriages, each drawn by a pair of white horses, were provided by Mr. Leggett for the accommodation of the visitors, and the procession which between the hours of 8 and 10 P. M. wended its way through avenues, streets and alleys aroused the curiosity and criticism of the numerous small boys gathered on various corners. Although a general feeling of skepticism pervaded the minds of the tourists as to the merits of tower lighting, it was almost entirely dispelled by a thorough examination of the actual illuminating power of the lamps which had been so judiciously located. The spirit of opposition to the system which exists in some quarters, is due without doubt to the industrious efforts of some of the local newspapers which take special pains to point out the fact that some of the streets are not illuminated as they should be. All of the visitors present were familiar with street lighting in other cities, and many of them were well aware that the apparent darkness in some spots, was chiefly the effect of contrast, and when the ground was reached, it was perceived that the reflected light from various points was really effectual in producing a moderately illuminated space even where the overhanging trees seemed to make it impossible. The pole lamps which were located here and there were devoted to the lighting of occasional corners which escaped the direct rays from the towers, and the limited number of these required, prove the generally satisfactory character of the whole system. While tower lighting may not be adapted to the requirements of every city, authorities who are considering the question

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of street lighting should not consider their mission performed until they have visited Detroit, and trust to the evidence of their own senses, rather than to the conflicting opinions of the average eye witness. Let them compare the illumination of the most unpretentious streets and alleys with that prevailing in other cities; let them go to the apparently dark spots, and prove to their satisfaction that they appear gloomy merely by contrast, as a secluded nook in a forest appears black as compared with the brilliant rays of a midday sun. The magnitude of this tower lighting enterprise, and the possibility of its not meeting the expectations of its progenitors, was certainly a most creditable exhibition of faith and pluck. Knowing the widespread interest which has been taken in the system the inspection was carefully made, and we have endeavored as nearly as possible to state the exact facts.

Two electric railways of the Van Depoele type were visited by many. One of these is at Windsor, Ont., and the other in Detroit. They use overhead conductors, with a traveling connection.

A very enjoyable excursion was planned for Thursday evening by the Brush Electric Co., of Detroit, who chartered the elegant lake steamer *City of Cleveland*, which sailed from the foot of Wayne street at 4 P. M. for Lake St. Clair, returning at 8 P. M. Several gentlemen were deprived of this pleasure, being obliged to leave the city for home before the hour fixed for the return of the boat.

First day's proceedings, Tuesday, Aug. 31. The meeting was called to order at noon by Vice-president Weeks, with the following remarks.

Gentlemen:—Mr. Morrison sends word that owing to the sudden and serious illness of his wife he cannot be with us. To say that so popular a member of our association and so efficient a presiding officer will be greatly missed, and that he has our keenest sympathy and best wishes in his affliction, will, I feel sure, express but a small portion of our appreciation of our president. The executive committee has prepared a programme consisting of fourteen topics of vital importance upon which members have been chosen to open the discussion.

You do not need to be reminded of the history and growth of our association, or of the pleasure and profit derived from our meetings in Chicago, New York and Baltimore to awaken your interest in the present convention; but it may not be amiss to emphasize the necessity for the closest attention to matters in hand, and the fullest interchange of opinions and experiences. Thus only can the maximum benefit of our intercourse be secured. It is my further pleasure to introduce to you one who needs no introduction to some, but who desires to know you all, and to assure you of his welcome, Mr. Wells W. Leggett, president of the Brush Electric Light Company, of Detroit.

Mr. Leggett feelingly expressed the pleasure felt by himself and his business associates in welcoming the members to Detroit. A programme had been arranged for their entertainment which combined business with pleasure. The new and elegant lake steamer *City of Cleveland* had been specially chartered for a trip up the river and lake, returning at an hour which would enable them to take a water view of the tower lights with which the city was illuminated. The steamer, which was the largest in the lake service, was fitted up throughout with the Brush-Swan incandescent system, and an opportunity would be afforded for its thorough inspection. A tour through the city in carriages had also been provided for, and it was the intention of the local company to see that the visiting gentlemen should be shown all phases of the tower lighting system.

At the conclusion of Mr. Leggett's welcoming remarks the roll was called. Forty-five names were responded to, many of the companies and firms being represented by two or more delegates, as follows:

New Haven Electric Light Co., New Haven, Conn., James English; *Electrical Review*, New York, C. C. Haskins, C. W. Price; Brush-Swan Co., Boston, Mass., Frank Ridlon; Brush Electric Co., Philadelphia, A. J. DeCamp; Southern Electric Co., Baltimore, T. McCoubray, Jr.; Fort Wayne-Jenny Electric Light Co., Fort Wayne, Ind., Perry A. Randall, and R. T. McDonald; Jarvis Engineering Co., Boston. Mass., H. A. Glasier; Allegheny County Light Co., Pittsburg, Pa., S A. Duncan; Riverside and Oswego Mills, R. T. Robinson; Callender Insulating and Waterproofing Co., New York, W. O. Callender; Schuyler Electric Light Co., of Hartford, Conn., Stephen Holbrooke; Springfield Electric Light Co., Springfield, Mass., J. W. Hyde; Pittsburg Carbon Co., Pittsburg, Pa., George F. Porter; Bridgeport Electric Light Co., Bridgeport, Conn., H. D. Stanley; Electric Supply Co., Chicago, Ill., C. H. Cone; Parker-Russell Mining and Manufacturing Co., St. Louis, Mo., T. R. Russell and G. W. Parker; Kansas City Electric Light Co., Kansas City, Mo , E. R. Weeks; Forest City Electrical Works, Cleveland, O., W. B. Cleveland; William Baxter, Jr., Baltimore, Md.; National Carbon Co., Cleveland, O., W. H. Lawrence; *The Electrical World*, New York, T. C. Martin and Clarence E. Stump; Brush Electric Co., Detroit, Mich., W. W. Leggett and W. H. Fitzgerald; Brush Electric Co., Cleveland, O., William F. Swift; Bridgeport Brass Works, Bridgeport, Conn., Fred H. Mason; Western Electric Co., New York, F. W. Harrington; Western Electric Co., Chicago, Ill., Frank Stewart; Newport Illuminating Co., Newport, R. I., J. English; McKeesport Light Co., McKeesport, Pa.; C. Latshaw, Chemical Electric Light and Power Co., Boston, Mass., A. V. Garratt; St. Joseph Electric Light Co., St. Joseph, Mo., Joseph A. Corby; American Electrical Works, Providence, R. I., George L. Beetle; Arthur Stewart, Baltimore, Md; Jenney Electric Light Co., Minneapolis, Minn., Arthur S. Hickley and Brainerd Rorison: Merchants Electric Light and Power Co., Boston, Mass., F. A. Gilbert; ELECTRICIAN AND ELECTRICAL ENGINEER, New York, R. W. Pope; Okonite Co., of New York, George Manson; Northern Electric Light Co., Philadelphia, Pa., G. W. Boyer; California Electric Light Co., San Francisco, Cal., George H. Roe; Schuyler Electric Light Co., Philadelphia, Pa., Stephen Holbrooke; Solar Carbon Manufacturing Co., Philadelphia, Pa., S. B. Richards; Sun Electric Co., Woburn, Mass., Frederick Swift and M. M. Slattery; Brush Electric Light Co., Savannah, Ga., T. P. Keck; Brush Electric Light Co., Niagara Falls, N. Y., Benjamin Rhodes; Edgerton Motor Co., Philadelphia, Pa., N. H. Edgerton and W. E. Sharp; Brush-Swan Co., of Norfolk, Va, C. E. Chamberlain; Troy Electric Light Co., Troy, N. Y., F. A. Cheney.

Letters were read accepting honorary membership, from Dr. Werner Siemens, of Berlin, and Mr. John T. Sprague, of Birmingham, Eng. Dr. Siemens also stated that he had forwarded for the library of the association, copies of his publications. The executive committee then reported the order of business adopted, which was carried out with a few exceptions and changes.

The secretary's report showed a membership of 125, an increase of 13 since the last meeting.

Dr. Otto A. Moses, chairman of the committee on the proposed bureau of information, submitted the following report:

REPORT OF COMMITTEE ON STATISTICAL BUREAU.

A statistical bureau of the National Electric Light Association shall be established under the direction of a chief and under the control of the executive committee.

The chief of the bureau shall receive a salary of ——————.

His duties shall be to establish an office in the city of New York, in which shall be kept records of all information collected from and distributed to the members of the association.

He shall collect and classify all patents as they issue in this country, and gradually do the same with all that have already appeared.

He shall examine all English, French and German patents as they appear, and shall remark on all new inventions contained in them that may be of interest to members of the association.

He shall classify and file all patent decisions on electrical subjects.

He shall collect documents, catalogues and such statistics as may be useful in all departments of electrical distribution.

He shall correspond with all members of the association, and request from time to time information for the special and exclusive use of the members of the association.

On application from the members of the association he shall endeavor to procure such desired information as may be obtained from other members.

On request he shall endeavor to collect such other information as may be demanded, for which reasonable fees shall be charged subject to control of the executive committee, or of a subcommittee, appointed for that purpose; such information being in the nature of abstracts from scientific papers, journals, correspondence, opinions, testimony, drawings, etc.

The expenses of said bureau shall be met by dues to be paid by the members of the association according to the following classification:

Local companies shall pay — cents per lamp per annum.
Supply companies shall pay $— per annum.
Parent companies shall pay $—per annum.

Mr. De Camp said that while all appreciated the importance of such a bureau, he considered its establishment at present beyond the means of the association, and moved that the report be placed on file for future consideration.

On motion of Mr. Boyer, an amendment was adopted that the report be referred to the executive committee for attention.

Mr. Duncan, from the committee on tabulating rates for public lighting, stated that no report had been prepared, and in the absence of the chairman, he would report progress and ask for further time, which was granted.

Mr. Ralph W. Pope, chairman of the committee on a standard wire gauge, presented the following report:

REPORT OF THE COMMITTEE ON STANDARD WIRE GAUGE.

Your committee upon a standard wire gauge, which was to confer with other associations, and advise upon the expediency of advocating state or national legislation for the recognition of a uniform gauge, begs leave to respectfully report that, notwithstanding a very general expressed desire by all parties interested, that some universal standard be adopted, no steps have been taken as yet by manufacturers to bring about such a result. As

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the present movement in the direction of adopting a standard was originally introduced by a wire manufacturer, it was supposed that by the co-operation of the various electrical associations, a general reform might be inaugurated. It is difficult to devise a gauge free from all objections, and it is hardly possible that progress can be made without the active support of the actual drawers of wire. The general tendency on the part of both producers and consumers, who desire accuracy in the filling of orders, is to furnish a sample or specify the diameter in thousandths of an inch, with further stipulations in some cases as to the weight and resistance. This practice will, no doubt, continue, even should a standard gauge come into a more general use, while in the present condition of affairs, there appears to be no other safe course to pursue.

Whatever gauge may eventually be adopted, it must necessarily be based upon actual measurement according to recognized existing standards, and consequently it appears doubtful whether the actual fractions of an inch, which are to conform with a certain number upon a gauge, is a proper subject for legislation. It is a well-established custom in many branches of trade to designate sizes by arbitrary numbers, but however desirable it might be that the products of different makers should correspond, this is not always the case. It, therefore, appears that where a size can be properly designated, based upon a legal inch, it is scarcely within the scope of legislation to fix upon an arbitrary number to represent the same thing.

This subject, wherever introduced, has given rise to lengthy discussion without material progress. and while it is entirely within the province of this association to assist in all reforms of this character, it is extremely doubtful if anything can be accomplished without the co-operation of the manufacturers, and we would, therefore, respectfully recommend that any further action upon this subject be devoted to securing their influence in actually introducing a standard wire gauge.

Following this report. Mr. Pope read a letter from Mr. F. R. Welles, of Antwerp, in which the writer stated that measurement by millimetres is the general practice on the continent of Europe. Mr. Welles, in his letter, quoted MM. Houry, Aboilard & Co., of Paris (large manufacturers of fine magnet wires), as stating: "The English wire gauge has never been in use here, and, without exception, all the orders we get from the different nations on the Continent indicate in hundreths of a millimetre the size of the wires ordered."

Mr. De Camp inquired what the objection of the wire companies was to adopting a standard gauge, and called on Mr. H. D. Stanley, of the Bridgeport Brass Company, of Bridgeport, Conn.

Mr. Stanley said he knew of none. He thought the wire companies were ready to accept any standard gauge. The National Telephone Exchange Association had adopted the new British standard gauge last September; yet he knew of but two companies that were using it. The new British standard gauge had been adopted by the English government; but consumers, in this country at least, had not adopted it.

Mr. F. W. Harrington, of the Western Electric Company, was called upon, and said he could only substantiate Mr. Stanley's remarks. A standard gauge that the consumers would wholly adopt he thought would be acceptable to the manufacturers. Orders were filled now by whatever gauge ordered.

Col. Geo. L. Beetle, of the American Electrical Works, New York and Providence, said the companies adopted a gauge and then didn't live up to it. If the companies would stand by one gauge, the manufacturers would.

Mr. A. V. Garratt, of the Chemical Electric Light and Power Company, Boston, favored placing the gauge of wires on the basis of the ohm, having reference to the conductivity of the wire. It might require considerable experiment on the part of the manufacturers, but when once the work should be done, thought it would be very valuable.

On motion of Mr. De Camp, a committee of three was appointed to prepare a report on this matter, and present with table at next convention. Messrs. Garratt, Stanley and M. M. Slattery (of the Sun Company, Woburn, Mass.), were appointed on the committee. Convention adjourned to 3.30 P. M.

AFTERNOON SESSION.—TUESDAY, AUG. 31.

After calling the meeting to order, Vice-president Weeks, resigning the chair temporarily to Mr. De Camp, read a paper entitled: "A Protest Against the Enforcement of Electrical Subways." (See page 379.)

The chairman called upon Mr. Pope, of New York, to state what progress was being made in New York toward the solution of the underground problem.

Mr. R. W. Pope, of New York.—The arguments which have been so freely used by the various parties interested in aerial wires against placing them underground, are now employed by the underground people in their quarrels with each other. Recently we heard of an application by a company organized for placing wires underground, for an injunction against any proceedings on the part of the New York Subway Commission, because this company had obtained a franchise and had spent $25,000 in getting ready to do something. I am very certain that they have invested nothing in plant, although possibly a considerable amount in organization expenses and experimenting; yet they hold that it is entirely wrong for anything to be done by the subway commission which will render this $25,000 a loss. This is very conclusive proof that if it is wrong that a company that has no plant should lose $25,000, it is far more wrong that other companies having valuable plants should lose perhaps ten times that amount. The various electric companies have valuable plants in New York which will have to be thrown away when they are compelled to place their wires underground. The Western Union Company, in New York, intend to place their wires in a tube under Broadway as far as Twenty-third street, and then they will go through Twenty-third street underground to Third avenue, where they will attach their cables to the structure of the elevated railroad and carry them in that way to Harlem. That is not an underground system exactly, but it will get the wires out of the way.

The system which is to be adopted in New York is, as nearly as I can understand it, made up of various patents and plans which were presented to the commission. Out of I think 119 plans the commission selected those which they considered the most feasible, and out of them was made a combination plan and that is the plan of the Consolidated Electrical Subway Company. The work of excavating for the subway was to have been commenced last Monday, but I am not aware whether anything was done or not. The work laid out is in a part of the city—Sixth avenue and Twenty-third street—where it is not essential that the wires should be placed underground.

Mr. C. C. Haskins, of Chicago, said: We have in Chicago a large number of wires in conduits of various kinds. We have an iron tube with asphaltum covering on the outside and inside to protect it from oxygen. We have a wooden box with an asphaltum bottom to it, wires laid in iron pipes inside of that, and the whole covered with asphaltum and boarded in, and we have iron pipes without any asphaltum. I believe the telephone company has placed its wires permanently in plaster in a wooden box. Then we have the Dorsett conduit—perhaps more of that than of the others. The city's wires are all underground. The telegraph companies are gradually putting their wires under, and we think we will have all of them pretty much out of sight by the time the snow flies.

Mr. De Camp.—Would you feel from what you know of what has been done in Chicago that any company having a large amount of money invested in their plant would be justified in transferring their whole business to that system?

Mr. Haskins.—It is hard to answer that question categorically. If a man has a plant worth $100,000 and he is compelled to transfer that $100,000 from the air to the ground, it is a pretty serious question, On the other hand, if I were to build, I personally should prefer to go underground on the principle that saving at the spigot and wasting at the bung is not profitable, and I think a line underground can be maintained at less cost than one overhead.

Mr. De Camp.—That is, supposing you are starting the business?

Mr. Haskins.—Yes, sir.

Mr. De Camp.—If I were going to make the experiment, I would make it in that way.

Mr. Leggett, of Detroit.—I was at Washington recently, where they had buried the wires in plaster, and it had proved a failure. They were obliged to take them out on F street, after a trial of a couple of years, and put them on poles. They were compelled to put them underground on Pennsylvania avenue, and they have had a great deal of trouble with them. The evening I was there one of their machines was running dead on account of a difficulty on their lines on Pennsylvania avenue, the locality of which they could not discover. I would like to ask Mr. Pope just what the system is in New York.

Mr. Pope.—I would say that the basis of the New York system is a drawing-in-and-out arrangement, that is, a series of ducts similar to those laid in Chicago. The conduit is square, and about 12x14 in size. There are ten ducts in a prism. This objection was raised to any system of imbedding the wires, that in case of any defect it would necessitate the digging up of the streets, which was always considered an objection; so the idea of imbedding the wires solidly was thrown out altogether. Some of the telegraph companies also object seriously to any system of that kind. I might say in regard to the concrete that was put down in Washington, that Mr. Stewart told me that on testing he found its insulation to be considerably higher than when it was put down.

Mr. De Camp.—I am glad to see that this matter is assuming a shape which is encouraging for a final solution of the problem. Municipal authorities now realize that there was an element of sincerity in the expressions of the companies in the earlier stages of the controversy. The authorities who have the power to destroy the business of the electric light companies by a simple vote of their respective bodies, have come to the conclusion with the electric companies that they could not put their wires underground. The city of New York has got to spend, as a city, a

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great deal of money before the scheme can be commenced to be proven, and I do not apprehend, if this association continues to evince an honest interest in the matter, that we will be harassed by arbitrary and unreasonable requirements on the part of municipal bodies.

Replying to a request for further information regarding the subterranean work accomplished in Chicago, Mr. Haskins read extracts from a paper prepared by Prof. John P. Barrett, and read at Providence, August 24, before the National Association of Fire Engineers.

Mr. DeCamp.—I think we can settle upon one fact—that this question of burying wires has got to come into one general system. The New York commissioners recognize that already. You can imagine what the condition of the streets would be, if every system undertook to maintain its own service of underground wires. There has got to be an accommodation for all those wires in one general system. I do not want to accept a position in any conduit where there is not some entirely disinterested party—disinterested to the extent, at least, of the compensation that I pay to that company—having entire and absolute control over it. If a city adopts the system of subways, which, as far as I can see, is the only possible way of solving the problem, they have got to assume control of that, absolutely, and the most rigid control. If you refer back a few years to the reports of Mr. Barrett, you will find the dangers of electric light wires dwelt upon, and the possibilities were very much exaggerated. I do not mean to say wilfully, but from want of knowledge. That has gone now out of question. The danger is more from interference with firemen. In the city of Chicago they present quite a large mileage of wire. Now, in Philadelphia the street in which the poles are most heavily laden with wires is probably Market street. On the north side of Market street, I think there are probably eighty wires on that line of poles. That is a big mileage. I am informed by the chief of the department that one-third to one-half of the wires on those poles are dead wires—wires that were live once, but from change of service fell out of use, and through fear on the part of the companies that if taken down they would never get them up again, were left there. In one effort to put wires underground in Philadelphia, they had 160 in a conduit. From time to time they dropped off. The last I heard of it, only five live wires were left. I have often thought whether that was not the case in Chicago—whether a large part of the mileage in Chicago was not dead wires.

Mr. Haskins.—Those wires in Philadelphia, I presume, like the wires in Chicago, were strung just after the law was passed and before it took effect forbidding the stringing of wires. In Chicago that law allowed companies a certain time to finish stringing the lines they had then in hand, and the companies pressed into service everybody they could get hold of and strung all the wires they could, because they knew by-and-by they would be stopped. Those we call dead wires, I think those in Philadelphia were the same.

A paper upon "Some Features of Incandescent Lighting and Wiring" was then read by Mr. T. C. Martin.

At the close of the reading Mr. DeCamp said that as it was a subject which would absorb a great deal of time, and as gentlemen were absent from this session whose contributions to the discussion he would like to hear, he moved that the meeting adjourn till 10 o'clock Wednesday morning.

Mr. Leggett asked permission, before the question was put, to present to the attention of the members some facts in connection with the tower system of lighting which there might not at any other time be as good an opportunity for doing, and which it would be of interest for them to know before going on the carriage tour of the city, proposed for the evening. He said:

We are lighting 21 square miles. We light entirely from one station. Among our circuits we have one of 20 miles in length, with 15 towers upon it. We have 122 of the towers with 4 lights each. We have 78 pole lights. We would call your attention to the towers, which we think peculiarly suited to city lighting. A tapering tower 150 feet high has a spread of 29 feet at the base. The impracticability of using such a tower for city lighting is obvious. The towers here in Detroit stand on one leg, and another advantage is that boys cannot climb up them. Suburbs which ordinarily are not lighted at all are the best lighted portions of our city, and suburban residents are strongly in favor of the electric light and the tower system. It was stated by our ex-chief of police that the police more than any others would miss the towers. The total number of city lights is 576, all of 2,000 c. p. Our towers are 150 feet in height; three are 175 feet where the buildings are very high. We average four lights on our towers. They are lighted all night every night. Our contract with the city is $114,500, and that includes $4,500 for the lighting of the City Hall by gas, which we pay for.

The meeting then adjourned to 10 o'clock Wednesday morning.

SECOND DAY'S PROCEEDINGS.—WEDNESDAY, SEPT. 1.

Vice-president Weeks called the meeting to order at 10 A. M., and announced that the subject for discussion would be that of incandescent lighting, postponed from the previous session.

Mr. De Camp.—I will start the subject by saying this, that in our experience with the incandescent light, so far as furnishing a light satisfactory to our customers and to ourselves is concerned, we have succeeded. We are doing 50 per cent. better work in all directions than we were doing a year ago, or even six months. But we still find great difficulty in the breakage of lamps running on arc light circuits. Could we overcome that, we would have a business worth pushing. The ratio of breakage of lamps running on direct machines does not correspond with that of lamps running on arc circuits. We have tried to run incandescent lamps in connection with arc lights, but separating the two. This has been an improvement, but not so great an improvement as we thought it should be.

Mr. F. A. Cheney, of Troy, N. Y., said:—We did not find incandescent lights on arc light circuits to be profitable, and we abandoned them about a year ago. We are now running about 1,000 lights in multiple series successfully and profitably. As to putting wires under floors, I think it is a dangerous practice, especially in old buildings, as whenever the floors are cleaned the water will go through and wet the wires and cause trouble. The great difficulty in running incandescent lights on arc circuits comes from the continual pumping action of the current, caused, I suppose, by the arc lamps. I have found no incandescent lamp that could stand that pumping action of the current. To run it successfully it is better to separate the two. We use 375 of these Little-McDonald cut-outs, and run the lights in multiple series. We use no distributors now. We had one or two in use.

Mr. Haskins.—I would like to call attention to one point as a matter of information. In one case that came under my observation the wire was run next to the wall, underneath a single molding. The wire used was the kind known as underwriters' wire. That wire, with all the proper appliances in the way of cut-outs, produced a fire in the molding, and for some time it was a question how it was done; but eventually it appeared that the water closet on the floor above had no pan to it, and consequently any leak would work its way down through the wall. Electrolytic action set in. The cut-out was not disturbed, because the smaller the wire became the less current it carried, and consequently the safer the cut-out. The wire finally cut itself off, and the fire continued until the current had made a cross circuit to the other wire and the safety strip melted.

Mr. Ridlon.—In buildings heated by steam the walls become impregnated with steam, which condenses and creates a dampness, by which the wire resting on the naked walls covered by the molding is very apt to be destroyed, and we are not aware of the danger until it is entirely past, or the accidental conflagration has occurred.

Mr. R. T. Robinson.—Our insurance inspectors will not let us run incandescent lamps on arc circuits. Mr. Woodbury said at our meeting at Baltimore, that it was not safe. The great trouble from wiring is not from water. I would much rather run either incandescent or arc wires under water than through a place where the temperature varies to a great extent, or where there is a great deal of steam. I wish some one had that experience in wet places, and could advise me how to avoid that trouble. I do not mean places where water is standing—I do not care for that—but where steam, and the changes in temperature are such that the condensation leaves a moisture just enough not to be called solid water, but a good thick mist—a Scotch mist.

Mr. Rhodes said that at Niagara Falls they were using water power, and had a good many Swan lamps running very satisfactorily from their Brush arc circuits. These incandescent lights were used in connection with a Brush box, both 38 and 92 volts. Some of them were located several miles away from the station, some of them over in Canada. They crossed the river twice with their wires, but not under water. "We do not use barrels for the protection of our wires, either, but they cross on one bridge and come back on the other. One of our circuits is 12 miles long. We find no difficulty whatever in using these lamps at that distance from the dynamo. But I have come to learn more about wiring. Our wiring has been done by men who have grown up in the business with us, and the only lessons they have had have been the lessons of experience. The question of wiring is a serious one, and one on which I with a good many others, need instruction." In reply to questions, Mr. Rhodes continued: "We are running, in the usual way, seven 38 or sixteen 92 volt lamps from these distributing boxes. I am sorry to say we have not had any way yet of keeping a record of the life of the lamps thus run, in hours. We run our lamps either for all-night business or for half-night business, and those who run for part of the night are permitted to burn their lamps until 10 o'clock in some cases; those lamps burn all the way up till 10, 11, 12 and 1 o'clock. With a number of boxes, I suppose the average burning will be from one hour before sunset until 10 or 11 o'clock at night. We keep account of our breakage, not by hours but by the month. We find that for the last three months our breakage has been three lamps per month, to each set of seven. For some reason or other not quite clear to us, the breakage is becoming less and less. The longer we use the lamps, the fewer give out. Whether the manufacturers are making the lamps better, or whether we are learning to run the dynamo more steadily, and to keep our current

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more regular, I am not prepared to say; but certainly we are gaining in that respect. Thus the breakage will now be about two per month, to each set of seven, which would be 24 in a year. Any one can figure out the expense of that, and will find that it is not a remarkably serious item of expense, as this is practically almost the entire expense of running. How this would be varied by running by steam I am not prepared to say, but I believe that as we run by water power our current is much more regular than it can be made by the best steam engines; and, I believe, that in that respect we have an advantage over steam engines. Another point is, our expense is so very little on other items that we consider this breakage to be our principal item of expense. Our entire cost for horse-power is $15 per h. p. per year, including the rent of the building and the installation of the wheel. We do not own the wheel, but rent power. As the power required for seven 38-volt lamps is considerably less than a horse-power, the power expense is very small indeed. The expense also of the men who take care of these lamps is very small indeed, because it is delegated to the lamp trimmers, and occupies very little of their time. The success with us is so great that it is at least satisfactory. The lights are satisfactory to our customers, and the prices are as satisfactory to us as to them."

Mr. De Camp.—You speak of a breakage of two lamps per month for a group of seven. That is the 38-volt lamp. Does the same rule apply to the 92 in groups of sixteen?

Mr. Rhodes.—We have not had enough experience yet to strike an average. On the two sets that have been running a few months, our breakage has been considerably less in proportion. That may be because we have not yet reached the life of the first lamps we put on. I think that on our three sets for three months, the breakage has been only about two per set—only about the same number in the sixteen of 92-volts as in the seven of 38-volts. The 16 c. p. lights easily take the place of a 5-ft. gas burner. They are run on the same circuit as the arc lamps, but we have been advised that if we put our entire number of incandescent lamps in groups, on a circuit by themselves, the breakage would be still less. But we cannot do that without doubly covering our entire district, and we prefer to continue doing as we are, with a single system of wiring covering our entire territory, sandwiching in among our arcs the incandescents, just as they happen to come. We charge in all cases $1 per month for each incandescent lamp. We get $7 for each set of seven. Where we put in the sixteen we make $1 reduction, leaving the charge $15 for the sixteen lamps, a slight inducement to the customer to take the additional number. We add 50 per cent. to that for lamps that burn all night. For arc lights we receive $8 per month, single lamps, and $10 double lamps. In some cases we find that we have been obliged to substitute the incandescent lamps for the arc, whether we wanted to do it or not, and I believe that has been found to be the experience of others, as already stated. There is a call for incandescent lamps, no matter how well the arcs burn—and ours burn as well as anybody's. Nearly all the customers who occupy small stores, as is the case in small towns, and to a great extent in large towns, prefer the incandescent lamps to the best possible arc lamp in existence. We find that there is a call for these incandescent lamps from those who have been using arc lamps. We find that there is not a very great difference between the profit of one and the other, and we try to balance one against the other at those prices which I have named. We are very much pleased to substitute the incandescent lamps for the arc. We try to fix our prices so that it will be as satisfactory to ourselves in one case as in the other, and then we let the customer make his own selection.

Mr. Weeks.—Do you furnish the wire and fixtures, or charge that to the patrons?

Mr. Rhodes.—That is a question that has come up several times —what to do with fixtures. At the present time, we are in a transition state, I may say, looking for advice and trying to learn from experience and that of others. We have not yet arrived at any conclusion. I think the one we will arrive at will be to insist on having everything done well, and, if necessary, to put in our own fixtures. We will put in a fair fixture, not an extravagant one, and adopt two or three different styles. We will put in such for you at our own expense, doing the entire work and paying for it ourselves, not charging the customers either for the wiring or for the glass globes and shades in connection. This point of charging for fixtures has become a serious one in cities where there is a good deal of competition, and in order to get the business, one company and then the other will make sacrifices, and hence the companies have come to do all the work themselves without any charge to their customers. Of course where there is only one company, and that has all the business it can get, it can make the charge against the customers what it pleases. In small towns like our own, where it is necessary in order to get a large amount of business to make some sacrifice, it comes to be nearly a necessity to do the thing yourself. That is a matter to be judged of in each community separately. We believe that in the way we propose to adopt, we can get our wiring done more satisfactorily to ourselves, and that we can obtain a sufficient additional number of customers to make it profitable to ourselves. We have had quite a little trouble from poor wiring and from hanging incandescent lights with poor fixtures. We find that it will pay us to furnish proper fixtures, even if they are combination fixtures, having them well insulated and the incandescents properly attached

Mr. Ridlon.—How long a time do you make a contract with your customers?

Mr. Rhodes.—For a year. But we have come to the conclusion that whether a customer signs a contract or not it is rather immaterial, because if we have a customer who is dissatisfied with his lamp from any reason whatever, it is much better for us, if such a case should happen, or for any other company, to take the light out immediately and release the man from his contract than to insist upon his using the light against his will until the close of the time. It is better for the company to see in the first place whether the man will continue; and if he is not likely to continue, it is best not to put in the lamp at all. There are a great many such cases where arc lamps have been forced into stores and saloons, where they were not at all appropriate. I have known cases where contracts have been signed and the customer forced to use the light, when the contract ought never to have been made at all. We believe that in such cases it is better to discontinue the light entirely.

Mr. Garratt said he did not believe that with any system of light, whether electricity, gas, kerosene or candles, the party supplying the light should be called upon to furnish the fixtures, too. Any man wishful to have the light was willing, he thought, to pay for wiring and fitting up the house. It was thus with gas, and he did not see why an electric lighting company should not be similarly disposed.

Mr. Duncan wanted to know who stood the breakage of the lamps.

Mr. Rhodes.—The company, I suppose, in all cases furnish the incandescent lamps, when breakage happens. Certainly our company does.

Mr. De Camp.—On the question as to who should repair the lamp. If they charged the customer with half the breakage, that seemed to be equitable. He thought that a company with a number of these lights on an extended system and entirely responsible for the breakage could not afford to neglect them, and that the attendance on them to the extent of inspection would be very nearly equal to that on the arc light. If, however, the parties using these lights knew that when broken the lights were to be replaced at their expense, they would undoubtedly take better care of the property than if the case were reversed.

Mr. Gilbert said that in New England they had been running 125 c. p lamps on the arc circuit for about three months. They had not believed in it before. They now found they could use them in multiple series without the box, and could certainly get three of them for less than a box would cost. They made their estimates as to the necessary life of lamps, and as to the price that should make them willing to displace the arc. If the lamps lived 400 hours they were going to put in more. Next convention he would know and tell the difference found in the profit on that basis. For some of them the average time now is 500 hours. They were getting a great deal longer life than they estimated. If the lamps lived 100 hours, they would still get their money back, but not make any profit. He found there was a field for the large incandescent lights just below where the arc lights stop, with people who felt they could not afford the arc light; and they could put in ten of them where they put in one arc light in the dull season. They could run them any distance, and they were perfectly safe. Their insurance inspector was satisfied with them. With the guarantee of the inspector and the experience they had they were going to increase their commercial business much more than with the arc system. As for small incandescent lights, they were just beginning to use them, but had not gone far enough to give any information about them yet, as to whether they would be profitable or not.

Mr. Bowen.—There is no doubt that a light of say 125 candle-power would become very popular if it could be properly put into use. I have had no experience with the incandescent light, but I believe that there is a demand for smaller lights than arc lights, and in our place we find that a number of merchants are putting the incandescent lights in their windows.

Mr. Slattery, of the Sun Company, was called for and said:—It seems to me that at the present moment we are able to overcome all the difficulties that have hitherto rendered efforts in the direction of high-tension distribution very discouraging. Our company—I speak with considerable reserve about this, as it may look like an advertising statement—has been endeavoring to meet a rapidly-growing demand for a suitable system of high-tension distribution. We make a box that we think enables people who are using arc lights to distribute to their high-tension circuits almost as if they were dealing with low-tension, and I came here to hear the verdict passed upon these things which we have been supplying. As the weeks—not the years—go by, I think that the subject of high-tension distribution will receive greater and greater attention.

Mr. Rhodes.—There are a good many members of this convention who would like to know a little more about Mr. Slattery's box. I think a description of it from him would be pleasing to

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almost everyone who is considering the question of electric lights.

Mr. Slattery.—The description of our box would be perhaps rather lengthy, and give rise to a great many technical expressions that perhaps would be tedious. A few minutes' examination of the apparatus in practical use, will be a great deal more satisfactory to you. But I might say a few words as a sort of preparation for the inspection which I shall be glad to have you make. Our box has been constructed, first, with a view to economy. As you turn lamps out of circuit you do not in all cases waste the energy in useless resistances, as we so construct the box that when you turn a certain number of lamps out of circuit, the box automatically cuts out those resistances that otherwise would be used for the purpose of wasting energy. Another feature of our box is that you can use large and small lamps controlled by the same apparatus. We use varying multiples controlled by the same apparatus, and I believe that the high-tension circuit can be so disposed that it can be worked as economically as a low-tenison circuit. We can make our box as variable as the demands of the customer may be.

The Chairman.—Mr. Robinson mentioned several obstacles encountered by him in connection with incandescent wiring. I think Mr. Haskins can probably give him some suggestions that will be valuable.

Mr. Haskins.—The only suggestion I could make for meeting the difficulty stated by Mr. Robinson would involve something like advertising, and I do not want to do that. There are wires which will resist the influences he describes. I know there is a difficulty, however, when you get down to the lamp itself, which it is almost impossible to get rid of. The condensation there bridges over from one pole to the other of the lamp and makes mischief. I call to mind a case in a tannery that I inspected. We found a very low insulation throughout the building. In experimenting, we took off all the lamps, and we found that after the lamps were off insulation was much higher than when they were on. There was no wiring under moldings in the buildings. Every lamp was suspended from a good insulator, and as few insulators as possible were used to support the wires. The principal leak was at the lamp itself. One remark in regard to positive and negative wires in the incandescent system. The underwriters claim the distance should be 2½ inches. Mr. Wirt and I tried a series of experiments on that point. We gradually brought the wires together until we got them within something like ⅜ of an inch. At that distance when we made a leak, the leak almost instantly connected the two wires and blew out the soft plug and melted the strip. In the case of 2½ inches with a wet board between them the board became a piece of kindling wood to take fire when the spark got ready to go across before any preparation for conflagration could be made.

Mr. Law.—In my experience with series multiple work I have put in a safety fuse in order to protect. I would like to know what has been the experience of some of the others in regard to that. I am in favor of using a safety fuse on both sides of the circuit. But in nine-tenths of the work going up down east, there is no safety fuse except on the loops.

Mr. Haskins concurred with Mr. Law as to the advisability of using fuses on both sides.

Mr. Duncan.—I think that this discussion shows that the combination of arc and incandescent lights in the same station, run as separate systems and then a combination of this series multiple for long distance lighting is the thing which we are about to arrive at. In regard to breakage we accord to the customer the privilege of paying for all the lamps broken and for paying for the wire ; he also has the privilege of using his taste in regard to fixtures and paying accordingly. For large spaces I find no disposition to displace the arc lights. In ordinary stores people like to have a light that is not turned on and off arbitrarily, but one that they can turn on and off when it suits them. The basis of our charge is one dollar a month for a 16 c. p. lamp, whether burned one hour or twenty-four. We do not use meters to measure how much light a customer uses.

This closed the discussion.

Mr. Pope read the following :

Office of A. G. Day,
Kerite Wires and Cables.
16 Dey St., New York.

Dear Sir:—In compliance with the resolution passed by the National Telephone Exchange Association and the National Electric Light Association, I beg to inform you that hereafter all catalogues and price lists issued by me will be made up and based upon the 'standard' wire gauge.

Yours truly,

CLARK B. HOTCHKISS, General Agent.

Mr C. C. Haskins then read his paper on "Wire Joints" (see page 377), after which the convention, on motion of Mr. De Camp, adjourned until half-past three.

AFTERNOON SESSION.—WEDNESDAY, SEPT. 1.

The afternoon proceedings were opened by the reading of a paper on "Carbons for Incandescent Lighting," by Arthur S. Hickley, of Indianapolis. (See page 371.)

One of the lamps referred to by Mr. Hickley, was located at the head of the main stairway at the Russell House, and attracted much attention, and the method of constructing the filament as given by the inventor was listened to with interest. In the discussion which ensued, Mr. Slattery spoke as follows :

Mr. Slattery.—In the exceedingly interesting paper read by Mr. Hickley some surprise seemed to be expressed at the fact that carbons of different resistances seemed to take more or less energy. I do not think there is anything to be astonished about in that condition, as it is perfectly familiar to us all that, owing to the various degrees of density of the filament, which cannot be perceived by the naked eye, the varying energy taken by these filaments results. Mr. Hickley said, also, that rapidly deposited hydro-carbon was rather a good thing, enabling the carbon to prove more refractory under the condition of the passage of the current. My experience has been that a very slowly deposited carbon is decidedly the more preferable. In rapidly deposited carbon you get the porcupine effect which he refers to, but in a slowly deposited hydro-carbon you get a close and dense polished surface which is decidely preferable for the longevity of the carbon itself. I think that the prevailing opinion is that the combination of animal and vegetable carbon is prejudicial to the life of the carbon because of the varying expansion of the two materials. I do not agree with the opinion that animal carbon is purer than vegetable carbon. Our method of purifying vegetable carbon or carbonaceous material is such that we are able to eliminate all foreign substances, and so get as pure carbon as it is possible to conceive of. Neither do I agree with the statement that it is desirable to introduce into the retort any volatilizable material such as camphor or oil, or any product of that character. I do not think it effects any good, because that material being very volatilizable is given off in gases very rapidly at a low temperature, at such a temperature too, that it will not affect the filaments themselves by leaving any deposit upon them. With regard to the last statement, made by the gentleman, that one volt lamp is a monstrosity of electrical efficiency, and I should rather see the lamp than dispute the gentleman's statement.

Mr. Hickley.—Mr. Slattery's line of research and mine are quite different. There are a great number of animal carbons that are of no use at all. The animal carbons would be broken into small pieces. But in this particular carbon such is not the case ; but it is so cemented and joined to it that it is almost impossible to see where the junction takes place. With regard to putting something into the crucible, I have been able to bake certain filaments with a small portion of camphor in the retort, when without that I could not get carbons at all. I know it is understood in the trade that a slowly deposited carbon is much better than a rapidly deposited one. I think I mentioned in my paper that a rapidly deposited carbon was very coarse indeed, and when examined through a microscope appears to have small lumps all over, only just united at the base. Nevertheless, it makes a very hard carbon, and more efficient, as far as I have been able to discover, than one that is slowly deposited. If you go too slow you get a soft mealy coating, which is not good, so far as my experience goes.

The paper prepared by Mr. Arthur Steuart, of Baltimore, was next read, upon the "Legal Relations of Electric Light Companies to Telegraph Companies, and to the Patent Office." (See page 372.)

After some discussion as to the feasibility of establishing such a bureau as was suggested by Mr. Steuart, the sentiment of the meeting seemed to be that it was not immediately practicable. The following resolution offered by Mr. Corby, of St. Joseph, was however adopted :

Resolved, That the legal committee be authorized to prepare such bills to be presented to Congress as may be necessary to carry out the suggestions (made by Mr. Steuart, for enabling the patent office to further the electrical business) and report them to the convention at its next meeting.

A very practical paper was then read by Geo. W. Parker, of St. Louis, on the "Adaptation of Carbon Points to Different Currents in Arc Lighting."

From the discussion which followed, it appeared that the exact reasons for the differences existing between carbons produced at the same establishment were still unknown, and that the manufacturers are desirous of obtaining such information from consumers as will enable them to remove all defects.

The meeting then adjourned to Thursday, at 10 A. M.

THE CLOSING SESSION, THURSDAY, SEPT. 2.

The meeting was called to order at 10.20 A. M., by vice-president Weeks.

Mr. De Camp, from the executive committee, referring to the establishment of a statistical bureau, reported that Dr. Otto A. Moses, of New York, and Mr. Arthur Steuart, of Baltimore, had been appointed to organize such a feature of the association, those gentlemen having undertaken to establish such a department without expense to the association as a body. Whatever charges may be made will be in the form of fees to be paid by the parties availing themselves of its facilities.

The executive committee also reported in favor of holding the next meeting at Philadelphia, in February, the exact date to be fixed hereafter.

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The action of the executive committee in both instances was formally approved by vote.

The treasurer, Mr. Cooper, reported through Mr. De Camp, that it was impossible for him to be present. The balance in the treasury was $550, and $110 had been received since, making the total available amount in the hands of secretary and treasurer, of $660. The association owes $1,200, and to offset the deficiency, the arrearages in dues amount to $650. The treasurer's report was accepted as made, and ordered placed on file.

Mr. De Camp, in response to a call from the chair for his report on the relation of parent to sub-companies, made the following verbal statement:

Mr. De Camp.—My report is a very short one. It will be remembered that at our meeting in February, the difficulty between the Albany company and the Thomson-Houston company came up, and a committee was appointed. That difficulty, I believe, was very satisfactorily settled. There has been but one instance, so far as I know, in which the committee would have had grounds for action, and that instance was not brought directly to the attention of the committee. That difficulty, I presume, has also been settled, though not definitely. It is likely to break out at any time.

The discussion which ensued developed the fact that many sub-companies are still hampered by contracts entered into in the early stages of the business, which handicap them in competing with organizations established under different auspices, which are enabled to take advantage of both experience gained and improvements introduced.

Mr. T. C. Martin, of New York, read a paper on the "Operation of Motors from Electric Light and Power Stations." (See page 375.)

Mr. De Camp.—On one point I have changed my mind very materially since our last meeting, at which I did not evince very much faith in the business arising from running motors It has been with much surprise that I have noted the great demand which there is for motors, and the prices people seem to be willing to pay for them. It is a business, I now see, that the lighting companies can do with profit.

Mr. Upton after again forcibly reminding the members that more money could be made in furnishing power than in supplying lights, said: Then, there is this railroad question. I believe in a few years every street railroad will be run by electricity, at half the cost of running street railroads now. What we want to run through the streets of cities are underground conduits. I was called to examine recently a system that cost $20,000 a mile. Mr. Van Depoele told me he had devised a system that would not cost more than $7,000 a mile. Another gentleman told me he could put in a conduit for $1,000 a mile. If you only push your power business as you push your lights, you will be astonished to see the number of people who can use small powers.

Mr. De Camp.—This thing has occurred in Philadelphia. A man will rent an attic and take a contract to make buttonholes for a large manufacturing house. He buys a motor. He is obliged by his landlord to move, and the only other place he can get is out of our limits. Now, his money is invested in the motor, but we can no longer supply him with the current. If we had a motor that we had confidence in, I do not know but what I would make two rules. I would say: "I will sell you this motor at a given price, or let you have it on rental." When parties own motors they have a pecuniary interest in your business, and they are more likely to keep up an interest in it.

Mr. Upton.—I have been speaking of low tension. I have never known a single motor to be burned out by running on low tension. I was looking at the railroad across the river this morning. It is a very heavy, clumsy sort of system. I asked the gentleman in charge what profit he was making. He said: "As nearly as I can figure it up it is nearly 75 per cent." "How do you make that out?" I asked. He said: "The road cost $9,000 and thus far it has paid $500 a month profit."

Mr. Harding.—With these low tension motors there is no trouble at all. In the Sprague motor there is no sparking. These motors are perfectly reliable in every respect. They are placed away in closets anywhere and require no care. We always sell the motors. I think there are three motors of that kind running which pay $180 a horse-power a year. We put on safety plugs, and in case you put on a certain load and vary the speed you simply blow out the plug and another one can be put in. They are more reliable, I think, than any steam engine I have ever seen. One motor we have runs 850 revolutions with a load, and about 845 without a load. So you can see there is no increased speed.

Mr. Stockley.—The Brush Electric Company thoroughly believe in the future of the motor business. We are now entirely ready, I believe, to go into it, with motors of a larger power than have been offered in the past, and we are likely to confine ourselves very much to this larger power, commencing say, with two horse-power, and running up to a hundred. Our attention has been called to taking the power of waterfalls and other cheap sources of power, and carrying it a long distance and using large amounts of power at the end—50 or 100 h. p. We are ready to-day to furnish motors that will run with absolutely steady speed, without a load or with a load, and we will furnish anything from 2 h. p. up to a hundred at about an average economy of 7 per cent. and every part of the mechanism is provided for permanent use and easy repair.

Mr. Law.—In general distribution of motive power in Philadelphia, we are running our motors on our arc light circuit. It would not pay us to run a separate circuit for our motor service, and that wire is over 22 miles long and covers a very large area, and it would be very troublesome to double that wire up.

Mr. Baxter, inventor of the Baxter motor, being called on by the chair, said: Motors can be made to run more safely on an arc circuit than on a multiple arc, for the reason that a motor standing still has a lower resistance than when running. When the motor runs there is a rise of potential between the binding posts, which is due to the counter electromotive force. If a motor is arranged so as to carry the current safely while it is doing its work, and the provisions made to guard against too heavy a current going through it fail, then the current will burn it out. On that account plugs have been provided to guard against that. With a motor constructed to run on an arc circuit nothing of that kind happens, for the reason that in an arc circuit the current's force is constant, and, therefore, no matter whether the motor is standing still or running, the heating effect of the current passing through it is always the same. Consequently, all that is necessary to do is to guard against sparking at the commutator, so that the brushes will not run out. We make our motors for all circuits, but there are probably 100 stations running arc lights to one running incandescent. The motors have to be wound differently for arc and incandescent circuits.

Mr. Upton.—I asked Mr. Sprague the limit at which he could transmit his power on his railway. I told him if we had to be confined to half a mile it would be of no account. He said that he could run twelve miles. I asked him what made the difference? He said there was no resistance, as with carbon filaments and incandescent lights, and that made all the difference in the world.

Mr. W. E. Sharpe, of the Edgerton Motor Company of Philadelphia, said: Before I entered in the electro-motor business I was engaged in manufacturing. I had a number of girls working, and Prof. Edgerton placed five or six motors upon heavy running machines in my shop. Those motors have not been touched. That is over a year ago. Nobody goes near those motors. The girl merely sees that the connections are all right, wipes off the commutator with a rag in the morning, and that is all that has to be done to it.

Mr. Ellinger, of New York.—It is not found necessary in practice, according to my experience, to have an expert workman to look after the machines. I had charge of Sprague motors in New York. They were for the most part 3 h. p. motors. These motors gave absolute satisfaction. We never had a burn out, and we never had men to go around and inspect. In order to keep the machine in good order it was absolutely necessary to keep it clean. That is about all there is about it.

Mr. Duncan.—We have a Sprague motor, 1½ h. p., running a fan and doing its work nicely. I look at this question of attendance in this way. Where the company owns the motor, or where the customer owns the motor, it is the duty of the company to look after the service that they give. If they allow the machinery to be neglected, they will consume more power in the motor. It is a simple thing for the carbon setter to be instructed in the care of these machines, and he can stop in and inspect them on his rounds and make a daily report of the condition of the machines, the same as he does of the lamps.

Mr. Law.—I have had a little over a year's experience with the Stockwell motor. I rented a few of them, but will not do it again. In nearly all cases we sell them outright. I am safe in saying that the expense of repairs is at least 50 per cent. less when the customers have to pay for those repairs. We have one 1 h. p. motor that has been running nearly three months. It is doing 1 h. p. of mechanical work. It runs from 7:30 A. M. to 5 P. M. It has never yet had any repairs excepting the trimming of the brushes. The motors, say 1-12th h. p., such as are used for sewing machine work, require oiling at least every two or three hours.

Mr. Boyer.—You will notice that girls will run sewing machines themselves and take care of them, and I think they could learn to take care of motors, which appear to be very simple in construction, as well as sewing machines. I think it would be policy to sell the motors.

In response to an inquiry from the chair, for information regarding the triple-thermic motor, Mr. Stockley said: The Triple-Thermic Company believe they have got a good thing. Theoretically we all know that bisulphide of carbon has an advantage over any other vapor in several particulars not necessary to specify here. The triple-thermic people claim that they have overcome all the practical difficulties they at first encountered. We are to test it for them. Prof. Haswell has made a report, in which he states that he obtained an efficiency from this motor, using bisulphide of carbon that indicated a saving of 74 per cent. in coal.

Mr. Upton.—The triple-thermic motor has been thoroughly

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exploded in New England. The Hartford Steam Boiler Inspection Company investigated that subject and published a thorough *expose* of the whole business, and you could not give one away in New England.

Mr. J. A. Pentz followed with a paper on the transmission of power to the dynamo, devoted to proper arrangement of the mechanical equipment of an electric lighting station.

Mr. Shultz in a few words enlisted the attention of the members to what he believed to be a vital question in the proper running of machinery, and hoped at the next meeting to present a paper upon the subject. He said:

In the paper just read you have touched on one of the most important factors in running all machinery, namely, belting. I will give you just one item to refer to, and then I will have to go. I belted up a very large plant, and I was sent for to go to the place and see about taking up the belt. I said: "That belt is too taut to take up; there is something wrong with your machine." I believe there was 5,000 lbs. tension on that machine. I said to the proprietor, "Let your dynamo back." He did so, and eased it every morning, and every evening tightened it out, and that belt has been running ever since without being taken up. If you will follow this plan, you will find a good deal less trouble in running your machines.

After the usual discussion upon the ever-prevalent topic of high speed *vs.* low speed engines, Mr. De Camp said:

I have thought that either on my own account or as chairman of the executive committee, I would, before the next meeting, ask the members to present plans for electric light stations (The apparently unexpected entrance of Mrs. De Camp, accompanied by two other ladies, afforded the first opportunity to turn aside from the thoroughly business-like character of the proceedings, which the speaker most happily availed himself of by the following interpolation).

Mr. President, there is no doubt of the success of this association. It is growing rapidly. At the last session we were favored with the presence of one lady. This year, we are favored with three. (Applause.) I was not very much disconcerted at the last meeting by the presence of one lady; but now I find I have lost the thread of my subject. (The dropped thread being picked up and handed to him by a neighbor, he continued.) Well, I think that could be very well done, because if it was known that this association had plans, open to the inspection of its members, made according to the ideas of people who have had more or less experience in building plants, the first thing persons wanting to build stations would do, would be to become members of this association.

There being no further business before the meeting, vice-president Weeks announced the closing of the final session in the following words:

Feeling that such resolutions have lost whatever meaning they originally possessed, we as a body, extend no vote of thanks to the authorities, or to our good friends of the electrical fraternity in this city, for the ample opportunities placed at our disposal, or the generous provision made for our entertainment. But our appreciation of these kind offices is none the less full and sincere, and we shall carry with us the most pleasant memories of our visit to this beautiful and hospitable city. Although most of the leading members of our association were unable to be with us, this convention has been one of increasing interest and profit—a fact full of encouragement, as it proves that our organization is based upon a living principle; that the National Electric Light Association is a resultant of the needs of the times rather than an ephemeral association of individuals brought together by chance or personal selection.

As we have finished our business as per programme, I declare the convention adjourned.

MANUFACTURERS' EXHIBITS.

The displays of electrical goods while not so extensive as at some of the previous meetings, were supplemented by novelties of special interest to the craft in the line of incandescent lighting and motors.

Clark B. Hotchkiss, in addition to the usual exhibit of Day's kerite wire and cables, distributed samples of spooled kerite tape in convenient form for a lineman's pocket. A circular announced that in future the catalogues and price lists from his agency would be based on the new standard gauge in accordance with the action of the telephone and electric light associations.

The Callender Insulating and Waterproofing Company showed samples of very heavy electric lighting cable for both submarine and subterranean work, also sections of four-hole conduit of asphaltum concrete.

The Okonite company, whose wire is being extensively used in Chicago, also exhibited various samples of their goods.

The Austrian cored carbons, manufactured by the Forest City Carbon Company were shown by the agents, Messrs. Holmes, Booth and Haydens, of New York. These carbons were shown in operation, and the steadiness of the light produced and the absence of any hissing sound, attracted considerable attention.

The Little-Macdonald cut-out for the introduction of incandescent lamps upon an arc circuit was in operation day and night up to midnight, when a sudden demand was made upon the gas burners in the room, caused by the shutting off of the outside circuits.

The Sun Company of Woburn, Mass., exhibited a number of their lamps of different sizes in conjunction with the Slattery box for introducing them on arc circuits. Three of the large incandescent lamps were located in the bar-room, where was also an installation of the Volta Pavia battery, consisting of 16 cells supplying five 8 c. p vitrite and luminoid lamps. This exhibit was made by the Chemical Light and Power Company, of Boston.

From J. F. Morrison's Electrical Works a very desirable volt and ampère meter was shown, especially adapted for electric light and power service. It was very highly commended by practical men, and was also a fine specimen of workmanship.

The Baxter motor formed a part of the same exhibit, and while no opportunity was afforded to test its efficency, its various points of merit, which were apparent to the casual observer, seemed to obviate many of the difficulties which have been experienced in letting motors for light manufacturing purposes. One of these motors was attached to a ventilating fan in the council chamber, but the temperature was at no time during the sessions, sufficiently high to make its operation desirable for comfort.

The Edgerton electric motor from Philadelphia, was shown in different sizes, and was highly commended for its extreme simplicity. These motors are already in practical use for light power, but the company is prepared to construct them of any required size.

The Pittsburg Carbon Company was represented by Mr. George F. Porter, to whom eastern representatives feel especially indebted for the most efficient manner in which he piloted the largest delegation present, from the rendezvous at Philadelphia to Detroit, and their safe return to such points as they desired to reach. Although unscrupulous in the frequency of his assessments, it is but just to say that there was always something to show for his efforts in promoting the comfort of the pilgrims under his charge.

The following is a complete list of members and visitors in attendance:

Anderson, J. Binghamton, N. Y.
Bailey, T. P., Chicago.
Baker, G. G., Akron, O.
Barclay, J. L., New York.
Baxter, Wm. Jr., Baltimore.
Beetle, G. L., New York.
Boulton, W. H., Cleveland.
Bowen, George S., Elgin, Ill.
Boyer, G. W., Philadelphia.
Buckley, W. J., Chicago.
Callender, W. M., New York.
Chamberlain, W. W., Norfolk, Va.
Cheney, F. A., Troy, N. Y.
Clarke, J. H., Youngstown, O.
Cleveland, W. B., Cleveland.
Cone, C. H., Chicago.
Corby, J. A., St. Joseph.
Cornell, R. B., Youngstown, O.
Crouse, J. B., Cleveland.
Davidson, W. F., Detroit.
De Camp, A. J., Philadelphia.
Dorsett, D. H., Chicago.
Duncan. S. A., Pittsburg.
Edgerton, N. H., Philadelphia.
Ellinger, J. O., New York.
English, J., New Haven.
Fisher, F. E., Detroit.
Fitzgerald, W. H. Detroit.
Fox, S. J., New Haven.
Frear, W. S., Buffalo.
Freese, H. G., Philadelphia.
Garratt, A. V., Boston.
Gilbert, F. A., New Haven.
Glasier, H. A., Chicago.
Harding, H. McL., Boston.
Harrington, F. W., New York.
Haskins, C. C., Chicago.
Hickley, A. S., Indianapolis.
Hine, H., New York.
Holbrook, S., Philadelphia.
Hotchkiss, Clark B., New York.
Hyde, J. W., Springfield, Mass.
Jackson, W. A., Detroit.
Keck, T. P., Savannah, Ga.
Keilholtz, P. O., Baltimore.
Kimball, W. R., Woburn, Mass.
Kreidler, W. A., Chicago.
Krout, W. B., Baltimore.
Latshaw, Z., McKeesport, Pa.
Law, M. D., Philadelphia.
Lawrence, W. H., Cleveland.
Leggett, W. W., Detroit.
Leggit, John T , Detroit.
Leonard, H. W., Chicago.
Libbey, E. D., Boston.
Little, F. P., Buffalo.
McCarty, N., Troy, N. Y.
McCoubray, T., Jr., Baltimore.
McKinlock, W. H., Detroit.
Manson, G., New York.
Martin, T. C., New York.
Mason, F. A., Bridgeport.
Parker, G. W., St. Louis.
Parsons, L. E., Chardon, O.
Pentz, James A., Philadelphia.
Pettingill, F. E., Cleveland.
Pfannkuche, A., Cleveland.
Pope, R. W., New York.
Porter, G. F., Pittsburg.
Possons. N. S., Cleveland.
Powers, W. T., Grand Rapids.
Price, C. W., New York.
Randall, P. A., Ft. Wayne, Ind.
Reid, J. H., Chicago.
Rhodes, B., Niagara Falls.
Rich, H. E., Cincinnati.
Richards, S. B., Philadelphia.
Ridall, J. E., Pittsburg.
Ridlon, F., Boston.
Ripley, H. C., East Saginaw.
Robinson, R. T., Olneyville.
Roe, G. H., San Francisco.
Rorison, Brainard, Indianapolis.
Russell, D. R., St. Louis.
Ryan, R. W., New York.
Sharpe, W. E., Philadelphia.
Sharretts, C. R., Baltimore.
Shaw, J. L., Grand Rapids.
Shay, J. H., Chicago.
Shultz, J. A. J., St. Louis.
Slattery, M. M. M., Woburn, Mass.
Smith, H. M., New York.
Stanley, H. L., Bridgeport.
Steuart, A., Baltimore.
Stewart, Frank, Chicago.
Stockley, G. W., Cleveland.
Stump, C. E., New York.
Swift, W. F., Cleveland.
Swift, F., Woburn, Mass.
Upton, A. F., Boston.
Van Depoele, C. J., Chicago.
Valentine, J. W., Cleveland.
Weber, J. C., Buffalo.
Weeks, E. R., Kansas City.
Wilkinson, C. A., Providence.

ANNUAL MEETING OF THE NATIONAL TELEPHONE ASSOCIATION AT ST. LOUIS.

The National Telephone Exchange Association convened in the large parlor of the Southern Hotel at 11 A. M., Tuesday, September 7, president C. N. Fay, in the chair.

The calling of the roll showed a good attendance by representatives of the various licensee companies of the American Bell Telephone Company, as well as of honorary members.

The president, Mr. C. N. Fay, delivered an annual address,

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largely devoted to exposing the popular illusion that the profits of the telephone business are inordinate.

The belief in the great profits of the telephone business, he said, was a popular fallacy. The number of telephones now in use was about one-fourth of 1 per cent. of the entire population of the country, and they could not hope to reach more than one-half of 1 per cent. of the population. It was only the business man, the capitalist who used the telephone. The workingmen, the laborers, had no use for them. The business was restricted to certain limits, which could probably never be overpassed. The city companies had had to face enormous expenses for underground lines; the companies doing country business had been compelled to carry out still further the process of closing and abandoning exchanges which had proved too small for self-support. City and country exchanges alike had suffered from legislative and municipal attacks upon their rates, and the whole business has been disturbed and unsettled by the government attacks on the Bell patents. He then proceeded to discuss at length the justice of the various attacks made on the Bell company and the various licensee companies. The stock of the American Bell Telephone Company, said Mr. Fay, is $10,000,000, now selling in the market for $19,000,000. Of this amount the shareholders actually paid into the company's treasury, in cash, $6,000,000, showing their profit to date to be $13,000,000. The licensee companies throughout the country are capitalized at about $54,000,000, selling in the market to-day for only about $25,000,000, an amount considerably below the actual money paid therefor, and below the actual cost of the plant and acquired business. There were undoubtedly individuals, the speaker admitted, who, in the manipulation of telephone stocks, had made considerable fortunes; but the broad fact remains that $15,000,000 would cover the entire amount of profit which the telephone fraternity have been enabled to exact from the suffering people during ten years of hard work, and add to their investment of $30,000,000 of capital say 5 per cent. per annum. On the basis of the last census this would be 3 cents. per annum extorted from each one of the suffering people. A comprehensive review of the telephone litigation, with caustic allusions to the action of the U. S. administration, concluded this very able address.

Secretary Barney submitted his annual report. The year, he stated, closed with 34 active members and 33 honorary members. The work of the office established in New York was reviewed, and the method of furnishing information to members explained in detail. The secretary presented the treasurer's report as follows:

Receipts, $2,312.05; disbursements, $2,311.15. A portion of expenses were for unpaid bills left over from the previous year; the actual expenses for year just closed being, $1,997.93. A portion of the receipts were in like manner for uncollected dues, the actual income for the past year being $1,887.05. On basis of present membership, with dues at $50.00, the income next year will be $1,700. Cash in hands, $133.35. The secretary stated that the association had no liabilities.

The secretary announced that the meetings of the convention would be held from 10 A. M. to 1 P. M., and from 3 P. M. to 5 P. M.

The election of officers for the ensuing year resulted as follows:

President, C. N. Fay, Chicago; vice-president, H. C. Metzger, Pittsburg; secretary, C. H. Barney, New York city; treasurer, H. L. Storke, New York city; advisory committee, Capt. H. N. Gifford, of Louisville, for three years, in place of Mr. Sunny. The committee now consists of Messrs. Gifford, Jackson and Tyler. Executive committee, Messrs. Sargent, Keller, Stone and Bailey.

The city of Pittsburg was selected as the place of the next annual meeting, the date to be selected by the executive committee.

Proposed changes in the constitution—laid over from the last meeting—were discussed, and adopted as follows, the changes being in italics:

"Article XIV., Section 1.—The admission fee shall in all cases be ten dollars, to be paid on signing the constitution. The annual dues shall be *fifty* dollars for each vote now had or that may be hereafter acquired under the constitution, and shall be payable yearly, on or before the first day of July in each year." (Proposed by the executive committee.)

"Article IV., Section 1.—The officers of this association shall be a president, vice-president, secretary, treasurer, and an executive and advisory committee, who shall, with the exception of *the secretary and* the members of the advisory committee, be elected at each annual meeting of this association, and shall hold office for one year, or until their successors are duly elected and qualified. *The secretary shall be appointed, for the ensuing year, by the newly-elected executive committee.*" (Proposed by the executive committee.)

"Article XVII., Section 1.—*Any person nominated by the executive committee may become an honorary member of this association by a vote of two-thirds of all the members present at any regular meeting, such election to be by ballot.*" (Proposed by Mr. E. J. Hall, Jr.)

The following additional article provoked considerable discussion:

Article XVIII. (additional article), Section 1.—*Any person or corporation actively interested in the objects of this association may become an associate member of the association by a vote of a majority of the members present at any regular meeting.*

Section 2.—*An associate member shall have no vote in the meetings of the association, but shall be entitled to all the other privileges of regular members, and shall be subject to the same dues and assessments.*" (Proposed by Mr. E. J. Hall, Jr.)

Mr. Metzger moved to strike out the second section, and spoke in favor of his motion; Messrs. Sargent, Seely and others opposed this motion. The motion was lost.

On motion of Mr. Easterbrook, Section 2 was amended by adding the words "except during executive session" after the word members.

The following change in the By-laws was proposed at the last meeting by Mr. H. L. Storke, and came up for action. It is an additional section to Article III., and was adopted:

Section 5.—*The secretary shall, under the direction of the executive committee, procure and compile for the use of the association such statistics relating to the telephone business as have heretofore been furnished by the various committees of this association.*

On the suggestion of Mr. D. I. Carson, cordially supported by Messrs Durant, Drake, Kerr and Easterbrook, a liberal contribution was made by the members of the association for the relief of the Charleston sufferers.

The secretary then read a paper on "Telephone Statistics," presenting them in tabulated and condensed form. "Reports had been received from 46 exchanges, representing 47,000 subscribers. Exchanges in cities of over 50,000 furnished the most valuable information for comparison. Of such there are 41 in the United States, representing about 63,500 subscribers. Of these, 23 exchanges, representing about 38,000 subscribers reported. Twenty-two exchanges had 33,112 subscribers in 1885, and this year report 36,634, a net gain of 3,522, or nearly 14 per cent. New York gained the largest number of subscribers, 791, an increase of 15 per cent., but as a comparative gain this record is beaten by that of Richmond, which gained 76, or 16 per cent.; by that of Detroit, which gained 329 or nearly 17 per cent.; and that of Brooklyn, which gained 443, or 19 percent.—New Orleans shows a loss of 44, due to an opposition company, which has recently been enjoined. Lowell and Worcester both show heavy losses, the former 213 the latter 132, due to a rise in rates. Detroit seems to be the field best supplied with telephones, there being one station to every 51 inhabitants; Providence coming next, with one to every 58. At the other end of the list Jersey City has one to every 232 of her population." A number of valuable tables were presented in this report showing an increase in the number of daily connections, and giving interesting comparisons. The eight offices working the "multiple" system average 623 daily connections per operator. The remaining 14 (reported) using "straight" boards average 309 connections per operator. New Orleans reports 1,054 as its operators' average day's work. Eight multiple boards average 81 wires per operator; 15 straight boards average 65 per operator. The number of trunk lines is shown to be increasing every year. New York pays the highest average salaries to operators, viz, $13.13 per week, and Milwaukee the lowest, $4.95."

Mr. T. D. Lockwood then read a paper on "The necessity of protecting telephone exchanges, circuits and appliances from the destructive effects of intense electric currents and discharges." He said that "two broad and comprehensive classes of protectors are more or less known, viz: Those in which a coarse wire electro-magnet included in the telephone circuit at the points to be protected is used to break the circuit, or shunt the instruments upon the passage of an abnormally strong current through the wires, the magnet being non-operative when the ordinary telephone or magneto currents are passing. And—Those in which an attenuated strip of metal foil or wire is made to form a part of the circuit outside of the portion to be protected, this having a sufficient conductivity for the ordinary currents, but being adapted to burn out, fuse, volatilize or deflagrate when a dangerous current passes. Protectors depending for their action upon electro-magnets are reasonably sure in their action, and are prompt, because the magnetizing effect of a current is swifter than its heating effect. On the other hand, electro-magnets in telephone circuits interpose a much higher opposition to the passage of the telephonic currents than might be expected from their resistance only, by reason of the counter currents generated in their coils by the changes in their magnetism." Mr. Lockwood, continuing, said: "I might well interpolate here that there is a method by which electro-magnets may be introduced into the telephonic circuit without exercising this pernicious effect, if the electro-magnets are connected in what we call multiple arc, that is, if the line wire be divided into two parts and brought abreast, one branch to one magnet and the other branch to the other magnet, and led through each magnet coil individually, then joined on the other side and led on as usual—to put it in plain language, connected abreast instead of connected in tandem. The counter current has a

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short circuit through those coils and does not materially affect the passage of the telephonic current, and although I had not written this, the sight of Mr. Wiley W. Smith here, who has always been an advocate of that method of connection, has reminded me of it at this time."

The small electro-magnet mounted on an insulated base, provided with the usual armature, which has a lever ending in a catch, which, when at rest, holds a spring lever in place, invented by Dr. S. M. Plush, of Philadelphia, was highly commended by Mr. Lockwood. In this the circuit is led through the magnet coil, armature lever, and spring lever, so that when the armature is attracted the spring lever is liberated and flies back, leaving an opening of some 6 or 7 inches in the circuit, and preventing damage to the instruments inside of the safety appliances.

On the conclusion of this paper the convention adjourned to 10 A. M. Wednesday.

WEDNESDAY'S SESSION.

Mr. H. L. Storke read an able and valuable paper on "The Legislation of the Past Year."—treating chiefly state and local legislation affecting the licensee companies.

Mr. J. E. Hockett, of Indianapolis, being called upon to state the result of the severe legislation in his state, said that the toll system had been adopted in the larger cities, but could not say whether it was satisfactory to the Central Union Company or not.

Capt Gifford said that his company had closed its exchanges affected by the $3.00 rental law, and was now operating a few long lines connected with the Louisville exchange at a loss for the accommodation of some customers.

Mr. Fay related his experience with the Indiana law, and reviewed the whole history of it, saying he regretted that no one was present to speak authoritatively for the Central Union.

Mr. Hall thought that in the toll system a guaranteed minimum was an absolute essential.

Mr. Fay's paper on "Cables and Underground Work" was read. He spoke at some length of the work in New York city, and the visit of the commission to Chicago. In the central district of Chicago, Mr. Fay said, they had one underground line 1,800 feet in length. It consists of kerite and Patterson cables, drawn into Dorsett conduits. The tests show that insulation runs down rapidly and cross talk increases.

The statement, by Mr. Fay, that the transmission of speech through cables was becoming less distinct each year Mr. Frost thought should be published at once for the benefit of telephone men. This change had been noticed by him.

Mr. Seeley stated that submarine cables nine miles in length, seven conductor kerite cables, were being experimented with in New York very satisfactorily. These cables were not in daily use.

Mr. W. D. Sargent, general manager of the New York and New Jersey Telephone Company, then read a paper on "Underground Work in Brooklyn."

Suggestive remarks by Capt. Gifford, Mr. Patterson and Mr. Hotchkiss were elicited by Mr. Sargent's paper.

After the reading of letters from M. Berthon, of Paris, and Dr. S. M. Plush, of Philadelphia, the convention adjourned for the day.

THURSDAY'S PROCEEDINGS.

The convention was called to order by vice-president Metzger, at 10 A. M.

The secretary read a paper, by Mr. A. S. Hibbard, on "Long Distance Telephoning and the Present Operation of Toll Lines." The paper embraced much that was useful and suggestive, and included the statistical table of toll line or inter-exchange statistics given at the end of this report.

Some pertinent discussion on the topic of Mr. Hibbard's paper followed.

A vote of thanks was voted to Mr. Durant for the excursion to Crystal City, and many other courtesies shown the members of the convention.

Mr. Durant presented an abstract, illustrated by blue prints, of a paper written by Col. Flad, president of the American Society of Civil Engineers, and president of the St. Louis Board of Public Improvements, descriptive of a plan of the author's for an overhead system of supporting and distributing, by means of towers and cables, electric light, telephone and telegraph wires.

Mr. Durant's synopsis of the paper was listened to with great interest by the members, and the secretary was instructed to prepare an abstract of the paper to be printed with the proceedings of the association.

The convention then adjourned.

Exhibits were made by the Western Electric Company, Standard Electrical Works, A. G. Day, Standard Underground Cable Co., Railway Telegraph Supply Co., Bridgeport Brass Co., Visual Signal Co. of New Haven, and of Wittenberg's telephone register.

The following named gentlemen attended the convention:

C. N. Fay, Chicago; J. R. Mulvane, Topeka; W. W. Smith, Chas. McDaniel, Kansas City; E. B. Field, Denver; J. J. Dickey, Flemon Drake, Omaha; C. H. Barney, Jno. A. Seeley, C. W. Price, R. W. Ryan, T. C. Martin, E. J. Hall, Jr., Col. Geo. L. Beetle, C. B. Hotchkiss, H. L. Storke, D. I. Carson, New York; E. V. Cherry, Cincinnati; C. P. Sclater, Chas. F. Sise, Montreal; W. D. Sargent, Brooklyn; A. B. Uline, Albany; W. N. Easterbrook, New York; Frank B. Knight, New Orleans; J B. Kerr, Harrisburg; W. A. Hovey, J. N. Keller, C. J. French, T. D. Lockwood, Boston; A. O. Morgan, New York; H. N. Gifford, Louisville; Geo. F. Durant, E. A. Hitchcock, St. Louis; H. P. Frost, New Haven; J. P. McKinstry, Cleveland; W. A. Childs, New York; C. F. Annett, Salt Lake City; T. B. Doolittle, H. D. Stanley, Bridgeport; R. M. Bailey, Williamsport; Geo. Manson, New York; C. A. Brown, W. R. Patterson, Chicago; F. W. Harrington, New York; C. D. Crandall, Kansas City; E. T. Gilliland, New York; M. R. Wolff, Wheeling; Frank Shaw, New York; J. E. Hockett, Indianapolis; Henry Metzger, Pittsburg; E. J. Hall, Sr., H. C. Palmer, Buffalo; J. K. Dunbar, Austin; R. S. Boyd, Boston; J. M. Brown, Washington; H. T. Crane, Cincinnati; J. M. Jackson, Chicago; F. E. Degenhardt, Pittsburg.

TOLL LINE STATISTICS.

Name of Telephone Company.	Mileage of poles.	Mileage of wire.	Exchanges connected.	Subscribers at these exchanges.	Toll offices connected.	Average No. of messages monthly.	Average rate per message.	Average monthly gross receipts per mile of wire.	Longest line worked successfully.
Central Union	7,655	10,460	122	15,500	614	68,900	22	1 45	75
Michigan Bell	2,238	3,421	68	7,205	203	40,000	20	2 39	145
New England	2,053	3,086	88	13,247	272	26,409	20	2 37	100
Wisconsin	1,942	2,538	65	4,288	163	11,953	28	1 98	199
New York & Pennsylvania	1,600	2,200	22	2,236	281	20,000	20	1 82	60
Central New York	1,561	1,903	16	1,412	325	22,858	15	1 80	60
Cumberland	1,157	1,392	17	2,821	134	8,800	25	1 60	65
Empire State	733	1,164	11	990	95	6,622	22½	1 29	80
Great Southern	603	936	6	1,311	94	5,547	32	1 89	142
Buffalo Bell	614	812	11	3,343	10	9,850	19	2 29	75
Delaware & Atlantic	675	783	50	2,073	28	7 500	20	1 69	65
Pennsylvania	488	605	33	2,360	...	2,365	15	59	74
Chicago	482	1,189	10	4,676	63	7,600	25	1 96	100
Nebraska	451	491	26	2,308	22	6,498	27	3 54	111
Central D. & P. Co , Pittsburg	412	830	30	3,338	37	....	25	1 43	135
Ohio Valley	370	510	3	1,585	32	3,642	22	1 58	156
New York & New Jersey	327	1,717	37	5,465	45	11,500	13	84	85
Central Pennsylvania	317	448	16	2,578	20	2,591	24	1 47	100
Colorado	294	294	6	1,151	6	7,194	18	4 52	114
East Tennessee	186	192	7	708	21	1,650	20	1 72	90
Missouri & Kansas	186	186	6	3,096	...	....	25	6 31	96
Missouri Bell	74	107	3	2,100	21	2,840	21	5 63	48

SUBMARINE CABLES.

The Pedro Segunda American Cable and Telegraph Company is about to lay a cable direct from New York to South America. At present when one wants to send a despatch to Brazil he must do so by way of Europe, at a cost of $2.06 per word. The new company promises a material reduction. Two and a half millions of American capital have been invested in this enterprise, and the company has been organized with H. K. Thurber as president, Edward R. Banero and H. W. Connor as vice presidents, Charles R. Flint as treasurer, and J. Edward Simmons as secretary. The cable and telegraph will be 4,000 miles long, and will be in readiness for business before 1887.

Sierra Leone has now been brought into direct communication with London, by the African Direct Telegraph Company's cables by way of Lisbon and St. Vincent (Cape de Verd).

ELECTRIC LIGHT AND POWER.

Domestic.

The Electric Illuminating Co., Chicago, Ill., has been incorporated. Capital stock, $25,000. William F. Dummer and others, incorporators.

The Sun Electric Co., Saco, Me., has been incorporated.

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Capital stock, $500,000. President, William Butterfield, Boston, Mass.; treasurer, Frederick Swift, New Bedford, Mass.

Olean, N. Y , will be lighted by electricity. For further information, address J. B. Smith.

The Deerpark Electric Light Co., Port Jervis, N. Y., has been incorporated. Capital stock, $30,000. George M. Beebe and others, incorporators.

The Malone Electric Light and Power Co., Malone, N. Y., has been incorporated. Capital stock, $25,000. Patrick H. Shields and others, incorporators.

A new electric light will shortly be introduced in the city of Chester, Pa. R. Packer and J. E. Cochran, Jr., are interested.

Marion, Ind., will be lighted with electricity. V. O. Irvin and Geo. B. Sweetser are interested.

The Lansdale Electric Light Co , Lansdale, Pa., has been incorporated. Capital stock, $10,000. Treasurer, Samuel Effing, Lansdale.

The Salina Gas and Electric Light Co., Salina, Kan., has been incorporated. Capital stock, $60,000. E. W. Pike, Chicago, Ill., and others, incorporators.

The Electric Light Co., of North Attleboro, Mass., will extend its plant to Attleboro and Attleboro Falls.

The Silver Electric Light and Motor Co., Cincinnati, O. Capital stock, $10,000. P. P. Lane and others, incorporators.

The Charleston Electric Light Co., capital stock, $50,000, has been organized at Charleston, S. C., with George B. Edwards, president, and P. P. Toale, secretary and treasurer, to build electric light works; have adopted Thomson-Houston system; ordered part of machinery.

The Maryland Electric Motor Co., capital stock, $250,000, has been organized in Baltimore to manufacture electric motors, by R. W. Baldwin, Wm. G. Wetherall, Jr., John H. Furman and others.

The Western Electric Lighting Co., Columbus, Ohio, has been incorporated. Capital stock, $25,000. George L. Converse, Jr., aud others incorporators.

The Zanesville Electric Light Co., Zanesville, Ohio, has been incorporated. Capital stock, $25,000. Geo. R. Fox, and others, incorporators.

The Greensburg Electric Light Co., Greensburg, Pa., has been incorporated. Capital stock, $6,000. Treasurer, William A. Huff.

The Ottumwa Electric Light Co., has been organized at Ottumwa, Iowa. Capital stock, $60,000. Attorneys, McNett and Tisdale.

The Schuyler Electric Light Company, of Knoxville, Tenn., has received the contract to light that city.

The Honesdale Electric Light Heat and Power Company, Honesdale, Pa., has been incorporated. Capital stock, $15,000. President, Martin B. Allen.

The Freeman Electric Light Company, Chicago, Ill., has been incorporated. Capital stock, $500,000. Arthur H. Chetlain, and others, incorporators.

Foreign.

Switzerland.—Two or three examples of the transmission of energy by means of electricity are to be seen in Switzerland, where there are plenty of waterfalls supplying the requisite motive power; but a company is now being formed which in many ways will be a model for others. It will have its headquarters at Montreux, will work an electric tramway between Vevey, Montreux, and Chillon, and will supply current for all purposes to the public. The company has a concession of certain rights for fifty years, and as it will get its motive power for nothing, will probably be a profitable undertaking. The population of the district is not large; but there are thousands of tourists during the summer who are sure to patronize the tramway, and the current is to be supplied to private consumers at such a rate that a lamp of 14 c. p. will cost, it is said, about a farthing an hour.

England.—Being dissatisfied with the price of the gas supplied by the Glossop Gas Company, Messrs. Rhodes have decided upon introducing the electric light into their large mill at Hadfield; 1,500 incandescent lamps will be fixed, and the work has been commenced by the Manchester and District Edison Electric Light Co.

The Union Bank of Australia, in Princes street, London, is about to have the electric light installed.

The yacht "Volta," propelled by electricity, started from Dover across the Channel to Calais on her trial trip. She reached Calais in 3 hours and 51 minutes from the time of her starting from Dover. She made the return trip from Calais to Dover in 4 hours and 15 minutes. The accumulators were charged only once for the whole voyage of 50 miles. The sea was very calm, and the passage was made so noislessly that a sea gull was not disturbed by the approach of the yacht and was caught with the hands.

At the invitation of Messrs. Shippey Brothers, London, a number of engineers, incandescent lamp makers and shareholders in electric light companies, met at the City Terminus Hotel, on August 26, to consider the position taken up by the Edison and Swan company towards the incandescent lamp trade. General Alexander having been voted to the chair, and having briefly opened the proceedings, Mr. Arthur Shippey addressed the meeting at some length, principally in condemnation of an alleged attempt on the part of the Edison and Swan company to obtain a monopoly of the incandescent lamp trade, as the result of the recent action between that company and Messrs. Woodhouse and Rawson. The decision given in that action, Mr. Shippey said, was to be appealed against, but the Edison and Swan company had taken hostile steps against other makers of incandescent lamps and their customers; and the object of his firm in calling that meeting was, he remarked, to see what could be done to frustrate the attempt which had thus been made to obtain a monopoly of the trade. He expressed the opinion that the time was not far distant when artificial lighting by electricity would be "a certainty" if parliament would help those who were engaged in the development of the enterprise, and that, with generating stations established, the electric light would be supplied at the same price as gas. The Edison and Swan company had an action pending against the Brush company and against his firm, who also had an action against the Edison and Swan company for interfering with their customers. On the motion of Mr. Lovering, seconded by Mr. W. H. Le Fevre, resolutions were passed expressing the opinion of the meeting that the course of action adopted by the Edison and Swan company towards customers using incandescent lamps and against the makers and vendors thereof was highly detrimental to the development of electric lighting; requesting Mr. Shippey's firm to defend the action referred to, and to avail themselves of every opportunity to fustrate the threatened monoply of the incandescent lamp trade by the Edison and Swan company; form a committee to watch over and protect the interests of the trade, and to assist makers and vendors of lamps and their customers in resisting the action of the Edison and Swan company; and finally, creating a general defense fund to enable such resistance to be offered. Messrs. Fyfe, Jöel, Tongue, Shippey, Lovering, and Le Fevre, and General Alexander, were appointed members of the committee, with power to add to their number.

MISCELLANEOUS.

New Incorporations.

The Campbell Curb Conduit Co., Minneapolis, Minn. Capital stock, $4,000,000. President, Miner Ball.

The National Electric Co., Chicago, Ill. Capital stock, $100,000. Edward J. O'Brien and others, incorporators.

The Musico-Electric Medical Apparatus Co., Chicago, Ill. Capital stock, $800,000. David M. Alexander and others, incorporators.

The Electric Mail Box Co., Chicago, Ill. Capital stock, $50,000. Frances W. Carey and others, incorporators.

The Summit Electric Manufacturing Co., Akron, O. Capital stock, $100,000. Jeremiah A. Long and others, incorporators.

The Northern Telegraph Co., Savanna, Ill. Capital stock, $100,000. George B. Harris and others, incorporators.

The St. Ignace Bell Telephone Co., St. Ignace, Mich. Capital stock, $10,000. William A. Burt and others, incorporators.

The Saginaw Electric Co., East Saginaw, Mich., has been incorporated. Capital stock, $50,000. W. A. Avery and others, incorporators.

The Market Indicator Co., Chicago, Ill. Capital stock, $50,000. Edgar H. Kellogg and others, incorporators.

The Combined Electric and Trip Bell Cord Co., Chicago, Ill. Capital stock, $500,000. William Glasgow and others, incorporators.

The Hurlburt Flexible Conduit Company, Chicago, Ill. Capital stock, $100,000. Daniel N. Hurlburt, and others, incorporators.

The Union Electric and Novelty Company, Denver, Col. Capital stock, $10,000. Thomas H. Patten, and others, incorporators.

The Great Western Telephone and Telegraph Co., Kirwin, Kan. Capital stock, $25,000. W. D. C. Smith, Washington, and others, incorporators.

The Julien Electric Co., New York city. Capital stock, $1,000,000. Wm. Brachen and others, incorporators.

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GENERAL NOTES.

Gutta-percha can be readily and simply vulcanized by making a concentrated solution in carbon disulphide, and adding thereto a solution of chloride of sulphur. The larger the proportion of the latter the greater the hardness of the resulting product, and by using about 15 per cent. of the chloride a body in every way similar to horn is obtained.

According to German statistics recently published on the railway enterprises of the world, the aggregate mileage at the end of 1884 was 290,750 miles. Europe claimed of this total, 117,694 miles; Asia, 12,757; Africa, 4,075; America, 148,738; and Australia, 7,486 miles. Not less than 60 per cent. of the whole mileage of the world is in English-speaking countries. Australia has the largest amount of railway accommodation in proportion to population, and the United States and Canada come next. The cost of constructing the universal railway system is estimated at £4,800,000,000. The highest expenditure was in Great Britain, where it amounted to £41,168 per mile, as compared with £24,797 in Belgium, £24,928 in France, £21,041 in Germany (state railways). £20,885 in Austria, £16,449 in Russia, and £12,650 in the United States.

ELECTRIC MANUFACTURING IN JAPAN.

A factory for the manufacture of telegraph wires and appliances is to be established at Tokio, Japan.

INVENTORS' RECORD.

Prepared expressly for The Electrician and Electrical Engineer, *by* Pope & Edgecomb, *Solicitors of Patents for Electrical Inventions*, 11 *Wall Street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From August 17th to September 14th, 1886 (inclusive).

Alarms and Signals:—*Apparatus for Signaling Policemen*, J. P. Brewer and W. C. Smith, 347,318. *Signaling Apparatus*, G. W. Brown, 347,319. *Automatic Electric Signal*, H. C. Nicholson, 347,634, August 17. *Thermo-Electric Damper Regulator and Alarm*, A. M. Butz, 347,866. *Electric Annunciator*, G. E. Painter, 348,045, August 24. *Automatic Fire Alarm*, T. H. Prescott, 348,473, August 31. *Automatic Fire Alarm System*, A. D. Wheeler, 348,707, September 7.

Clocks:—*Electric Clock and Indicator System*, T. C. H. Vance, 347,399. *Electric-Clock System*, C. L. Clarke, 347,572. *Illuminated Clock Hand and Dial*, A. Speer, 347,528, August 17.

Conductors, Insulators, Supports and Systems:—*Telegraph Wire and Insulator Fastening*, J. Wilson, 347,454. *Telegraph Pole*, H. C. Herron, 347,602. *Wire Joint*, C. McIntire, 347,625. *Telegraph Insulator*, J. O'Brien, 347,635, August 17. *Underground Conduit for Electric Railways*, C. J. Van Depoele, 347,905, *Insulator for Electric Wires*, J. M. Leonardson, 347,948. *Conductor for Electric Railways*, R. J. Harris, 348,006, August 24. *Testing Station for Conduit Systems*, J. F. Munsie, 348,572. *Machine for Covering Wire and other Cores*, J. C. Beck, 348,822. *Insulating Conduit*, W. W. Averell, 348,880, September 7. *Telegraph Wire and Insulator Fastening*, J. Wilson, 349,022. *Telegraph Pole*, J. E. Lippincott, 349,049. *Insulating Wire and Conductor for Electrical Purposes*, T. J. Pearce and M. W. Beardsley, 348,994, September 14.

Dynamos and Motors:—*Electro-Dynamic Motor*, C. J. Van Depoele, 347,902. *Regulator for Electric Motors*, same, 347,903. *Regulator for Dynamo-Electric Machines*, R. M. Hunter, 347,937. *Regulator for Electric Motors*, O. B. Shallenberger, 347,964, August 24. *Regulator for Dynamo-Electric Generators*, M. Deprez and J. Carpentier, 348,385, August 31. *Electric Current Regulator*, M. J. Wightman, 348,876. *Armature for Dynamo-Electric Machines*, A. Bossard, 348,883, September 7.

Galvanic Batteries:—*Voltaic Battery*, A. F. W. Partz, 347,440. *Battery and Battery Plate*, H. Woodward, 347,754, August 17. *Electric Pile*, J. B. Neyrand, 347,823, August 24. *Electrode for Electric Batteries*, S. L. Trippe, 348,482, August 31. *Galvanic Battery*, W. C. Goldner, 348,901, September 7. B. Jarriant, 349,222, September 14.

Lamps and Appurtenances:—*Arc Lamps*, L. G. Bronson, 348,512, F. Thone, 348,799, G. Pfannkuche, 348,927, September 7; E. and F. W. Heymann, 348,-971, 348,972 and 348,973, September 14. *Incandescent Electric Light Hanger*, H. P. Brown, 347,767. *Fusible Cut-Out*, C. G. Perkins, 348,048 and 348,049. *Night Lamp for Electric Lighting Systems*, J. W. Howell, 348,125, R. N. Dyer, 348,155, August 24. *Means for Suspending Electric Lights or Gas or Oil Lamps*, J. N. B. Moore, 348,407, August 31. *Electric Railway Car Illumination*, E. J. Wessels, 348,603. *Holder for Incandescent Lamps*, E. Weston, 348,647. *Electric Connection for Chandeliers*, J. P. Willets and E. R. Crolius, 348,708. *Hanger for Electric Lamps*, C. C. Haskins, 348,845. *Switch Socket for Incandescent Lamps*, M. J. Wightman and L. Hermann, 348,875, September 7. *Arc Light Regulator*, P. O. Kielholtz, 348,977. *Carbon Holder for Arc Lamps*, same, 348,978, September 14. *Electric Lighting System*, E. Weston, 348,649, September 7. *Street Support for Electric Lamps*, J. L. Renehan, 347,880, August 24.

Measurement:—*Ampère-Meter*, E. Weston, 348,648, September 7.

Metallurgy:—*Magnetic Separator*, G. A. Gilbert, 348,121, August 24. *Magnetic Ore Separator*, C. Q. Payne, 348,771, September 7.

Miscellaneous:—*Indicating Apparatus*, C. L. Clarke, 347,571. *Automatic Electric Liquid-Level Indicator and Controller*, J. J. Ghegan, 347,589. *Therapeutic Electrical Belt*, Ira Gray, 347,592. *Electric Current Converter*, R. A. Ripley, 347,642. *Electro-Magnetic Valve*, M. W. Grovesteen, 347,707, August 17. *Artificial Electrical Resistance*, H. P. Brown, and F. Herbert, 347,766. *Circuit-Closing Thermometer*, J. E. White, 347,851, August 24. *Receptacle for Poisons*, T. Mayhew, 348,227. *Safety-Catch*, W. S. Andrews, 348,371. *Medical Electric Belt or Pad*, J. McGrady and G. H. Sloan, 348,406. *Electro-Magnetic Adding Machine*, C. W. Weiss, 348,487. *Cut-Out for Electric Circuits*, J. M. Fairchild, 348,455. *Switch for Electric Circuits*, J. M. Fairchild and J. O'Connor, 348,456, August 31. *Electric Air Pump System*, A. B. Worth, 348,606. *Safety-Strip for Electric Circuits*, E. Weston, 348,646, September 7. *Means for Operating the Stop-Cocks of Gas-Meters*, L. Lenaerts, 349,109, September 14. *Medico-Electrical Apparatus*, J. R. Hard, 348,465, August 31. *Electric Time-Ball*, J. Böhling, 348,949, Sept. 14.

Railways and Appliances:—*Electric Train-Controlling System*, F. J. Mc Queen, 347,628. *Signal for Railroad Crossing*, W. Vogel, 347,752. *Railroad Signaling Apparatus*, same, 347,753, August 17. *Means for Storing and Utilizing Electricity on Vehicles*, C. E. Buell, 347,768. *Electric Railway Traveler and Switch Operator*, C. J. Van Depoele, 347,901. *Dynamo-Electric Railway Brake*, same, 347,904, August 24. *Electro-Magnetic Railway Brake*, same, 348,360, August 31. *Electric Railway*, S. H. Short and J. W. Nesmith, 348,476 and 348,477, August 31. *Electro-Magnetic Car Brake*, H. S. Park, 348,636. *Electric Tramway System*, M. H. Smith, 348,792, September 7. *Railroad Signal*, W. Hadden, 349,040, September 14.

Secondary Batteries:—*Manufacture of Secondary Batteries or Accumulators*, S. Farbaky and S. Schenek, 348,625, September 7.

Telegraphs:—*Telegraph System*, M. G. Farmer, 349,214, September 14.

Telephone Systems and Apparatus:—*Line Holder for Acoustic Telephones*, A. W. S. Davis, 347,325. *Telephonic Apparatus*, T. J. Perrin, 347,374, August 17. *Telephone Transmitter*, J. E. Dann and J. Lapp, 347,924. *Telephone*, T. A. Watson, 348,077. *Electrode for Telephone Transmitter*, T. A. Edison, 348,114. *Receiving Telephone*, O. Lugo, 348,134. *Telephone Switch and Circuit*, E. Pope, 348,139, August 24. *Mechanical Telephone*, L. B. Kenyon, 348,328. *Telephone Receiver*, L. Townsend, 348,429. *Telephone Transmitter*, same, 348,430. *Thermal Telephone*, W. Stanley, Jr., 348,501. *Telephone and Telegraph Circuit*, J. J. Carty, 348,512, August 31. *Mechanical Telephone*, W. H. Eastman, 348,896. *Telephone Switch*, W. C. Turnbull, 348,-936, September 7. *Telephone System*, C. Herz, 349,042. *Telephone*, same, 349,043, September 14. *Multiple Switch Board*, T. J. Perrin, 348,578 and 348,-579, September 7.

Sprague Electric Railway and Motor Co.,

16 & 18 Broad Street, New York City.

This Company is the Owner of Patents 313,247, March 3, 1885; 315,180 and 315,181, April 7, 1885; 324,891, August 25, 1885; and Twenty-six Others Issued to Frank J. Sprague for the Transmission of Power by Electricity.

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NEW YORK, NOVEMBER, 1886.

A NEW ERA IN DOMESTIC ELECTRIC LIGHTING.

WHEN in the early part of 1880 the announcement was made, apparently upon good authority, that the electric light for domestic use was "at last a scientific and practical success;" that with all its obvious advantages, it could nevertheless be furnished to the consumer at a price less than that charged for gas, and that systems of incandescent electric lighting from central stations were to be forthwith established in all our large cities; it was generally believed by the public to mark the beginning of a new departure in domestic illumination. While we will not undertake to gainsay that in a certain sense this was true, yet in common with other more or less conservative electricians, we were by no means so sanguine as to the prospect, from a dollars and cents point of view, as were most of the promoters and capitalists connected with the new lighting enterprises. A very simple calculation sufficed to show that the real problem in domestic or house-to-house lighting, was simply one of cost rather than of possibility of distribution; that this had, as yet, received but a partial solution, and that unless the financial question thus raised could be successfully disposed of, the contest for supremacy as between gas and electricity must, purely for commercial reasons, ultimately terminate in a victory for the old illuminant. In seeming disregard of these considerations, however, several central station plants on a large and costly scale were erected, most of which have now been in continuous operation for some years. While it is claimed that some of them, the New York down-town district in particular, are earning a fair interest upon the capital invested, the fact that no apparent disposition exists to extend the sphere of operation to other and presumably more profitable sections of the city, points to a contrary conclusion, and one which more nearly coincides with the results of the computations of disinterested electrical engineers. The well understood limitations of existing central station systems, in respect to the practicable area of each district, which cannot be taken to exceed half a mile in any direction, as well as the excessive cost of the conductors necessary to effect a reasonable economy in distribution, have led many inventors to attempt to overcome these objections. The results of these attempts may be divided into three classes;—first, the multiple conductor system, of which the "Edison three-wire" is an example, which permits the working potential in the conductors to be increased, and the consequent weight of the conductors materially diminished; second, the storage system, in which accumulators are charged by high potential distribution current and discharged by a low potential consumption current, and third, the induction system, in which a current of high potential is employed in the mains, and converted into a current of low potential by inductive devices situated at the places of consumption. The first of these plans somewhat diminished the cost of conductors and so far as it did this was unquestionably an improvement. The second, for well understood reasons, has proved but partially successful, but the third, which has been for a number of years in process of evolution, appears at the present moment, in view of practical experiments and extended tests on a large scale, to be completely successful. Although but little has been made public respecting the results obtained with the improved apparatus now employed, yet the matter has already excited a remarkable degree of interest and inquiry in electrical circles. The originators of the inductive system have but just received their United States patent, the claims of which we reprint in another column, which will serve to show the fundamental principles of the system. It is almost needless to point out that if the inductive system proves to be practically successful, a result which we now see no reason to doubt, it is scarcely too much to say, that the problem of economical distribution over any area required in practice in electric lighting has received a final solution. If this turns out to be the case, the displacement of the existing illuminating gas plants by the new incandescent electric system can be at the utmost but a question of a few years time.

ARGUMENT OF THE BELL TELEPHONE COMPANY'S PLEA TO THE JURISDICTION AT CINCINNATI.

IN the government suit to annul the Bell patent, the preliminary question of the jurisdiction, argued at great length at Cincinnati for five days in September, has not yet been passed upon by the court. Its determination is looked for with much interest by the legal profession as well as the parties to the suit. It has called forth from very able and distinguished counsel on both sides, elaborate argument and comprehensive citation of authorities, upon the question whether the American Bell Telephone Co., a corporation domiciled in Massachusetts, has been legally "found" in the state of Ohio, for service of process by the United States courts of that state in the present suit.

The writs were served upon officers of Ohio telephone companies, alleged agents or partners of the Bell company.

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The case was opened for the defendant by Mr. Storrow, and for the United States by Mr. Lowrey.

In behalf of complainant it was urged that the Bell company had in fact appeared to the merits, and waived the question of jurisdiction by pleading; that as the defendant's plea states that the Bell company is the sole owner of the patent, and that the other defendants (the Ohio licensee corporations) are neither agents nor partners, and as it states that the alleged cause of action arose in Washington, if anywhere, the plea contains a defense on the merits. Replying to this point, toward the close of his argument for the Bell company, Mr. Storrow quotes from the introductory part of the plea as follows: "This defendant appearing specially and solely to object to the jurisdiction of this court, pleads to the jurisdiction of this court over it, and for cause of plea says, and this defendant is not compellable to appear in response to said writs, and does not accept or waive service thereof:" and from the conclusion of the plea; "Wherefore this defendant prays the judgment of this honorable court whether it ought to be required to appear in accordance with any writ of subpœna issued in said suit."

Some of the leading points of Mr. Storrow's argument may be summarized as follows:

The Bell patent has been repeatedly sustained, and the record of all the cases is now in the Supreme Court. The attorney-general requests the Bell company to count for nothing all that the circuit courts have decided, and all that the Supreme Court may decide. He asks them to come to a distant forum in order to take up the burden of repeating the litigation. They naturally decline.

While there was a plain and unmistakable road open for the attorney-general to reach the Supreme Court, he has chosen to select one that is unusual, and has never been sanctioned by any decision in a similar case.

That a defendant should litigate his case where he lives, is a maxim of common law which the judiciary act has put into the federal jurisprudence and kept there for a hundred years. The attempt of the attorney-general to depart from that rule in this case, raises something more than a question of mere form. It is a question of the power of this court to compel this defendant to come here; a question of jurisdiction.

The judiciary act requires actual personal inhabitancy or presence in the district. The Supreme Court has often decided that neither the ownership of property, nor the transaction of business through an agent amounts to being "found." This being true of natural persons, is necessarily true of corporations. A corporation does business in a foreign state through its agent, if permitted by that state by express legislation, or by the comity that exists in the absence of legislation; but it exists, resides, and is "found" only in the state of its creation.

In cases where this rule of law becomes inconvenient, the Supreme Court decided that as to all matters within the substantial power of a foreign state, the technical difficulty could be removed by express legislation, but not without it. The legislation required and adopted was not a consent that a corporation might enter, but a requirement that when it entered it should do so through an agent authorized to receive service of process, as well as to transact business.

This case is an attempt to have this court destroy a federal franchise owned by the Bell Telephone Co., and to do it by a decree *in personam* against the corporation. For this purpose no statute can be invoked, even to bring the defendant before the court.

As to state statutes, and what corporations and what cases come within them.

It must appear that the corporation has brought itself voluntarily within the sovereignty of the state, by doing business, and that the authority invoked does not go beyond the just power of a state, nor the extent to which the corporation has subjected itself. The Ohio statute as to foreign corporations reads: "*When the defendant is a foreign corporation, having a managing agent in this state, the service may be upon such agent.*" It should be construed as covering, and intended to cover, only that class of corporations and cases which, in accordance with repeated previous decisions of the Supreme Court, came within the reason of that class of legislation and the just and ordinary power of the state. The state cannot reach in substance persons, property, or business which are in substance situated beyond its limits. As to the present case: in the party attacked; in the transactions sought to be investigated; in the character and origin of the right assailed; in the effects which would flow from the decree asked;—this case goes far outside of any possible authority of the state of Ohio. To enable a state to exercise sovereign powers *in personam* against a foreign corporation, it must have established its business within their limits, by an independent establishment of its own, and not as subsidiary to, nor as supplying means for carrying on the business of any local corporation. On this point Mr. Storrow cited the case of Tennessee *v.* Pullman Palace Car Co., finally adjudicated by the U. S. Supreme Court last year. The state sought to tax the car company on the ground that it did business in Tennessee. The cars of the company were run in and through the state under contracts with the Tennessee railroad corporation. In accordance with these contracts the Pullman company sent its own conductor and porter with each car; the railroad company hauled the cars without charge and kept the running gear in order; the Pullman company made no charge to the railroad company for the use of the cars, but got its pay by collecting the price of a sleeping car ticket from each passenger; that was all the pay it had, and it had all that was collected from the sale of sleeping car tickets. The railroad company permitted such sleeping car tickets to be sold at its ticket offices, making no charge for its agent's services in such selling, so that the railroad company's ticket agents became in effect the agents of the Pullman company; the money collected by them being for account and risk of the Pullman company. Under these terms every sleeping car ticket was a contract between the Pullman company and the passenger, made in the state of Tennessee. After going through state courts the question came before Mr. Justice Mathews, at U. S. Circuit, and finally before the Supreme Court (reported in 117 U. S., 34). Mr. Justice Mathews, and afterwards the Supreme Court, said: "The Pullman company has no domicil in Tennessee—" and further, "*the Pullman company carried on no business within the state in the sense in which the carrying on of business in a state is taxable by way of license or privilege.*" The Supreme Court held that the business which was

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done in Tennessee was a unit; that in the eye of the law the whole—carrying one class of passengers who paid one price in ordinary cars, and others who paid a higher price in better cars—was one business of transportation, carried on by the railroad company, and that the Pullman company furnished the railroad company with the facilities for doing that business. They held that the Pullman company did not carry on a business of its own in Tennessee.

As to *how and by whom the telephone business is carried on in Ohio*, Mr. Storrow gave an elaborate, frank and luminous exposition of the system devised and practiced by the Bell company for exploiting the business throughout the country; a scheme, which for the magnitude and complexity of its object, the difficulties to be overcome, and the intelligent adaptation of means to ends, must challenge the admiration of all who appreciate the task undertaken. Some of the chief points developed by Mr. Storrow were as follows: The Bell company sold to local companies the right to use the telephone in particular localities. By their forms of contract they carved out the telephone business into separate parcels, so that when a purchaser of one did what he had acquired the right to do, his work would join on with that of his neighbors, so that they should co-operate with each other for a system of intercommunication, and they sold to various local corporations all the rights and parcels so carved out. The meaning of the whole plan was that the Bell Telephone Co. should not control the business as an owner does, but should sell it out. Thus the Bell company has never built nor operated a telephone nor a line, nor has ever had an office, nor an officer, nor a servant, outside of Massachusetts. The Bell company furnishes telephones in Boston to local corporations; it does not furnish any anywhere else, nor to anybody else. The business of furnishing telephones for public use in Ohio is the business of the local corporations only, and not at all the business of the Bell company. The technical title to the ownership of the telephones is reserved to the Bell company. It is technical only, and is reserved to secure the rights of the Bell company, in the event of default in payment of royalty by the local corporations. The local corporations receive a right coupled with an interest in the telephones, in fact an *estate* in them for a determinate time, with a right of renewal.

Ownership of stock in Ohio corporations by the Bell company is not doing business in Ohio.

The complainants by their brief agree with defendants that the present cause of action is so far removed from state sovereignty that the foreign corporation act of Ohio cannot be invoked in this case. The law of the case must be found in the federal judiciary act, and decisions of the Supreme Court.

While it may be true, as claimed in complainant's brief that a corporation may be "*found* in a foreign state *for the purpose of being sued on contracts made there*; it cannot affect *this* suit. The cause of action in this suit did not arise out of a contract made, or out of an injury done, by the Bell company in Ohio.

The Bell company cannot be served as partner of the local company. It has no partnership contracts. It has not the capacity to be a partner.

A patent has no locality, and can only be reached by a decree *in personam.*

As to the marshal's return: "I served this writ on the defendant, the American Bell Telephone Co. (which is a corporation doing business and found within the eastern and western divisions of the southern district of Ohio, by reading the same to A. D. Bullock, the president of the City and Suburban Telephone Co., and delivering him a duly attested copy thereof, the said City and Suburban Telephone Co. being an agent and partner of the said American Bell Telephone Co., within said southern district of the state of Ohio)." Observe the parenthesis; as if the marshal knew he had no business to put it in at all. It is suggested by complainant that the return is binding and cannot be contradicted. The Supreme Court have in recent years so often affirmed that a court cannot create its power by asserting it, that it seems hardly worth while to discuss the question.

Mr. Grosvenor Lowrey, for the complainant, replying to Mr. Storrow, directed his argument to establishing the following propositions: That the Bell Co. was in fact doing business in Ohio, through agents; and that the service had upon such agents was good and valid for the purpose of the present suit.

Some principal points of Mr. Lowrey's argument may be stated as follows: It must be assumed that the contracts (licenses to the local corporations) are executed at the place of their performance; that is, in Ohio. The contracts for private line telephones—signed by the Bell company, and sent out in blank, to be filled out by the local company and signed by the individual users of the telephones,—is clearly perfected in Ohio, where it is delivered and is to be performed. The mere dating of a contract at a particular place is not conclusive.

In the language of their charter from the state of Massachusetts the Bell company was organized "for the purpose of manufacturing, *owning*, selling, using and *licensing others to use*, electric speaking telephones * * *, and for that purpose constructing and maintaining, *by itself and its licensees*, public and private lines and district exchanges, etc." The charter continues: "For the purposes aforesaid, said corporation *may become a stockholder in*, or *interested with* other corporations hereafter organized for like purposes, etc." Therefore, the business for which this corporation was organized may be performed whenever and *wherever* it either manufactures, or owns, or sells, or licenses, or uses, or licenses others to use telephones; or wherever it is found constructing or maintaining, by itself, or by its licensees, public or private lines, or exchanges. *Qui facit per* licensee *facit per se.* The Bell company can *own* telephones only where they exist; and so far as its corporate business of owning is carried on, it can be said to be done only where the thing which is the subject of ownership exists. The corporate *function* of owning telephones is exercised in Ohio, and the *business* of owning is, therefore, carried on in the state.

The powers reserved to itself by the Bell company in its contracts with local corporations constitute a further reason for holding it amenable to this jurisdiction. Some of these reserved powers are:—To limit the power of the local company to connect its own lines with other lines; to limit the right of the local company to allow its poles and structures to be used by other telegraph companies; to restrict the use of a local exchange to such of the public only as are willing to comply with the terms of contracts prescribed, and from time to time changed, by the Bell company; and to exclude all customers not satisfactory to the Bell company; and to fix, and alter from time to time, the amount of compensation to be charged by the local company to the customer. The decision on such points is a material part of doing business.

The Bell company owns a controlling interest in the stock of some of the local companies. In this system there is co-ownership, not strictly partnership, but co-ownership. The possession of one is the possession of all; and in respect to jurisdiction, the representation and responsibility of one should be that of all.

The arguments of Mr. Storrow and Mr. Lowrey, were reinforced by addresses from other eminent counsel on both sides.

We may be permitted to say that the argument for the jurisdiction of the Ohio circuit would seem to have much more force if the subject-matter of the suit were in any way local, and if there were not a direct and speedy way open to the government, for bringing it before the Supreme Court. The validity of the Bell patent must be finally adjudged there. Whatever the decision of the Ohio circuit, much time must elapse before an end is reached.

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ARTICLES.

DYNAMIC ELECTRICITY.

BY CARL HERING.

(Continued from page 371.)

CHAPTER V.

ARMATURES.—(*Continued.*)

The electromotive force induced in the armature depends directly on the velocity with which the active parts of the wire move through the field. This is commonly known as the "conductor velocity," though it ought properly to be called the "inductor velocity," as the wires moving through the magnetic field are the "inductors," or those in which the induction takes place; while the wires at the ends, and in the inside of a Gramme ring, are the conductors, as their only function is to conduct the current which is generated in the inductors. This inductor velocity will be greater as the distance of the moving wire from the shaft is increased, and as the number of revolutions is increased; in other words, the inductor velocity depends both on the diameter (or radius) of the armature, and on the number of revolutions; it is not a function of either alone, but depends on their product.

This inductor velocity should evidently be as great as it is practical to make it, for increasing it represents a direct gain in other parts. It is usually measured in feet per second, and may be calculated by multiplying the circumference of the armature, in feet, by the number of revolutions per second. As the diameter of an armature is usually given in inches, and the speed in revolutions per minute, the calculation may be simplified by multiplying the diameter in inches by the speed in revolutions per minute, and by .0044 approximately (accurately, .004363), which gives the result directly in feet per second. If greater accuracy is desired than that obtained by using the external circumference of the armature, allowance should be made for the thickness of the layers of wire, as the inside wires have a somewhat less velocity; therefore, instead of taking the outside circumference of the armature, it is better to take the mean of the circumferences at the outside and at the inside layer.

As this inductor velocity is dependent on the product of the diameter and the speed, it may be increased by increasing either of these, but from the mechanical considerations it is preferable to increase the diameter rather than the speed, because in doubling the inductor velocity, for instance, it is easier to double the diameter and run at the same number of revolutions, than it is to keep the same diameter and run at double the speed. There is also another reason why this is preferable, for by doubling the diameter, and, therefore, the circumference or surface of the armature, the same number of turns of wire will make only half as many layers, thus decreasing the distance between the pole pieces and the core, and very greatly decreasing the proportion of this distance to the diameter of the armature. An armature of small diameter is, therefore, running at a disadvantage, for with the same length of armature, same speed, current and number of turns on the armature, the electromotive force, and therefore the capacity of the machine, may be doubled, and at the same time the number of layers halved, by doubling the diameter of the armature, the only other change being a larger field to embrace double the area of armature surface, and a somewhat greater amount of dead resistance.

The best guide in selecting the inductor velocity to be used in dynamos, is to compare the results of practice in well-built machines. In a number of the best Edison machines[1] it varied from about 46 to 54 feet per second, for cylinder armatures varying from 10½ to 7 inches in diameter, the speed varying from 1,100 to 1,600 revolutions per minute. With the latter high speed the inductor velocity was only 46.5 feet per second for a 7-inch armature, showing, as stated above, that small armatures do not run as advantageously as larger ones. In several of the best Weston incandescent light machines, with 8 to 9-inch armatures and speeds from 1,050 to 1,250 revolutions per minute, the mean inductor velocity varied from 37 to 43 feet per second; while for some Weston arc-light machines it was as high as 61 feet per second. In a small Weston incandescent light machine with a 4½-inch armature, at 1,380 revolutions per minute, the mean inductor velocity was only 26 feet per second. A contrast to this small armature is the large 60 arc light Brush machine, which makes only 825 revolutions per minute, but has the very high mean inductor velocity of 72 feet per second; the mean diameter being about 20 inches, which shows the great advantage of large diameters of the armatures. Another flat-ring machine (Schuckert) had 65 feet per second. Hospitalier states that 66 to 82 feet per second for the middle part of the armature, is rarely exceeded; this, no doubt, has reference to Gramme armatures, and gives for the inductor velocity about 83 to 100 feet per second. A Siemens cylinder armature machine had as high as 107 feet per second, but this, as well as the previous one, no doubt exceeds good engineering practice. As a rule, Gramme armatures are lighter and larger in diameter, and can therefore be run at a higher inductor velocity than cylinder armatures, which is an important advantage over the latter.

One of the principal proportions in armatures is the relation between the length of the armature wire and the electromotive force which it is to generate. Although this is of such great importance, there is, strange to say, little or no practical information regarding it given in the numerous text-books. Elaborate theories and complicated formulæ have been published, but it is doubtful whether they are of much value in practice. The most reliable proportions are, no doubt, those which may be deduced from some of the best existing machines. The writer has, therefore, calculated some constants from the proportions of some Weston and Edison machines, which, though taken from entirely different machines—both arc and incandescent—agree so well that they can safely be taken as a reliable guide in determining what length of wire is required in the armature, to give a certain required number of volts. These machines were all of the cylinder armature type, but it is presumed that, if properly applied, the constants may also be used for Gramme ring armatures.

As stated in a previous chapter, the electromotive force is induced when a wire cuts lines of force, and therefore only that part of the wire is generating electromotive force which lies directly between the pole pieces and the armature core. This will be termed "active wire," in distinction to the dead wire at the ends of the armature, and that which is not embraced by the pole pieces. A few lines of force pass around from the outside of the pole pieces to the ends of the armature, thus rendering part of the otherwise dead wire active; some also pass obliquely from the thin ends of the pole piece projections to the armature core, thus rendering active some of the wires which are not directly between the iron of the pole pieces and the armature core. But as the intensity of the field is, or should be, so very much greater in the space lying directly between the pole pieces and the armature core, the small amount of induction in the other parts of the wire may be neglected. With this assumption, it was found that in several Weston incandescent light machines the total electromotive force generated was at the rate of from 1 to 1.3 volts for every foot of active wire, while from some rough measurements of several arc light machines of the same type, it was from 2.2 to 3.2 volts per foot, with a higher inductor velocity and a more intense field. In several Edison machines, of different sizes, it was from 1.5 to 1.8 volts per foot. It is assumed, in deducing these constants, that the field is uniform in all parts; this is probably

1. See table in present number, page 424.

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not the case, but it will not materially affect the values of the constants, as they may be taken to represent the average value for all the wires. Moreover, in calculating armatures, these constants are to be applied to conditions similar to those under which they were deduced, and the error will, therefore, be eliminated.

The electromotive forces induced per foot, as just given, depend on the speed as well as on the field. In order, therefore, to properly compare the results, and to reduce them to a form in which they may be used for different speeds, it is necessary to eliminate the speed, or, in other words, to divide these constants by the inductor velocity in each case, thus reducing them to the number of volts which would be generated if the active wire on the armature had a uniform velocity of one foot per second. In the Weston incandescent light machines this reduced constant was .025 to .030, which means that in every foot of active wire on the armature, .025 to .030 volts would be generated if the wire had a velocity of one foot per second. As the electromotive force is directly proportional to the speed, this constant must be multiplied by the velocity of the moving wire of any particular armature, in feet per second, to give the number of volts per foot which will be generated in that armature when running at the desired speed. In several Weston arc light machines, a rough measurement gave from .044 to .052 volts per foot for an inductor velocity of one foot per second, showing that the field was still more intense than in the incandescent light machines. In several Edison incandescent light machines of different sizes, it was .033 to .037, showing that the field was more intense than in the Weston incandescent light machines, but not as intense as in the arc light machines.

As these constants agree tolerably well with each other, they may be safely used in designing armatures for machines where the general construction is similar to these machines. Probably they could also be used for Gramme armatures, provided that only the active wire is considered, and that the magnetic field can be made as intense as in these Weston and Edison machines. The core of the Gramme armatures will, therefore, in most cases, have to be made larger than is customary, in order not to weaken the field by interposing too much magnetic resistance in the armature. How to apply these constants in designing armatures for generating a required electromotive force, will be more fully explained and illustrated in a subsequent chapter on the calculations of armatures.

These constants evidently depend directly on the intensity of the field, and vary with it, for if the intensity of the field were doubled, the values of these constants—that is, the number of volts per foot—would also be doubled. The magnetic fields of dynamos will be considered later; it will suffice to state here that the fields of the Weston machines had an intensity of magnetism of 18,000 to 21,000 useful lines of force per square inch of pole piece surface, while in the Edison machines this intensity was from 23,000 to 26,000; these higher figures are probably due to wrought iron being used in the field. In cases where the field is as economically proportioned and as well designed as in these machines, an intensity equal to these figures can be used in calculating armatures; but if the field is not as well designed, it is advisable to use a smaller intensity in calculating armatures, in order to be on the safe side.

Another important proportion in designing armatures is the size or cross-section of the wire used. This evidently depends on the current which is to flow through the machine and also on the amount of electrical energy which is to be lost in the armature. It is not simply dependent on the current, but is governed also by the number of volts per foot which are to be generated in the wire; for suppose, for instance, that four per cent of the total electrical energy is allowed as loss in the armature, which will be a certain number of volt-amperes or watts, and will represent a certain definite amount of heat which must be dissipated on the surface of the armature; from the constants given above for the induction per foot, the required length of wire can be calculated and from this length together with the volt-amperes which may be lost in it, the resistance and cross-section of the wire can readily be calculated. Now it is evident that if by any means this induction per foot of wire may be increased, for instance doubled, the length of the wire may be halved, and therefore, to have the same resistance, the cross-section may also be halved, which will decrease the amount of wire by weight to one-quarter of what it was before; now if the size of the cooling surface of the armature remains the same, that is, if the number of layers have been reduced to one-quarter of what they were before, the size of the armature remaining about the same, the armature will not get any hotter, as the amount of heat generated is the same and the cooling surface the same. The cross-section of the wire for carrying the same current has, therefore, been reduced to one-half of what it was before, without heating the armature more. This calculation will be modified somewhat, on account of the resistance of the dead wire in the armature, which was not considered in the above statement in order to avoid complication of the calculation. The great importance of increasing as much as possible the number of volts per foot is seen from the example just given, in which it was shown that in doubling the induction per foot, by increasing the speed or the intensity of the field, the amount of active wire, by weight, is reduced to one-quarter of what it was, for the same loss in the armature and the same current. This also represents a decreased self induction (provided the speed is the same), less sparking at the commutator, less counter magnetism of the armature, and less shifting of the brushes, provided the outside dimensions of the armature remain approximately the same. There will also be an increased intensity of the field, as the space between the pole pieces and the armature core has been reduced to about one-quarter of what it was.

In order to serve as a guide in preliminary calculations of armatures, certain values for the proportion of the cross-section of the wire and the current are sometimes given. A common rule is to use about three amperes per square millimetre cross-section, in which it must be remembered that only half of the current flows through a wire on the armature, because the two halves are in multiple arc. This, reduced to a more practical form in our own units, is equivalent to 520 square mils per ampere. In the Weston and Edison machines mentioned above, the following proportions exist: in the Weston, from 375 to 562 square mils per ampere; and in the Edison, from 400 to 500, where a single wire is used; and 475 to 600 for the sum of the cross-sections where two and three wires were used in multiple arc. These figures being taken from the same machines from which the constants given above for the induction per foot were calculated, they may be used in armatures in which the induction is about the same as in these machines.

Another important point in designing armatures is the thickness of the space occupied by the wire on the armature. As this depends on so many of the other proportions, such as the cross-section and length of wire, the diameter and length of the armature, the induction per foot, the speed, etc., it is hardly possible to give any definite rule. The general rule, already given in a previous chapter, is to make it as small as possible. The following constants taken from the Weston and Edison machines may serve as a guide. The percentage of the external diameter of the armature which is taken up by the windings on both sides (or in other words the double depth of the winding divided by the external diameter) was as follows: in the Weston machines 8 to 10 per cent. and in the Edison, 8.8 to 11.5 per cent.; that is, in a Weston armature of say 10 inches external diameter, the wire would occupy from .8 to 1 inch, making the thickness of the layers from .4 to one-half inch. Possibly this depth may be increased without decrease of

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effect, if iron lugs or projections are placed between the coils as in the Pacinotti ring armature, but this point we believe has not yet been conclusively demonstrated.

The distance between the pole pieec projections where they are nearest to each other, depends on the distance between a pole piece and the iron core of the armature, that is, on the depth of the armature windings and the clearance between the armature and the pole pieces ; for it is evident that the lines of force at this part of the field have the choice of two paths, either from one pole piece to the core and then from the core to the other pole piece, or else directly from one pole piece to the other ; in the first case they are rendered useful as they are cut twice by the armature wire, while in the latter case they are wasted, and represent leakage of magnetism. Suppose the distance between the pole piece projections was equal to twice the depth of the winding and the clearance, then the intensity of the field between them would be as great as the useful field between the pole pieces and the armature core at that place, and would, therefore, represent a considerable waste. The amount of this leakage would be dependent on the amount of surface exposed on the ends of these pole piece projections. The distance between the pole piece projections should be made as many times the depth of the windings as possible, not only on account of the leakage, but also to make the field as weak as possible, for the armature coils lying between these pole piece projections, as these coils are the ones which are short circuited by the brushes, and should be as free from induction as possible. To make this distance too great would diminish the amount of active surface of the armature too much. Perhaps the best guide is, to make this distance a certain number of times the distance between the pole piece and the iron armature core ; about seven to eight times is a fair proportion. In the Weston machines it was found to be about 4.75 to 5.75 times, while in the Edison it was from 4.4 to 8 times. By making it great, say eight to nine times, the brushes, for an armature with comparatively few windings, will require less, if any, adjustment for different loads, as the field is weakened in the place where the dead (short circuited) coils are.

Another rule for this proportion is, to make the distance between two pole piece projections about 10 to 12 per cent. of the whole armature circumference ; this will make the active surface of the armature about 80 to 76 per cent. of the whole surface, a figure which is very convenient to use in preliminary calculations of armatures. This is about the proportion which exists in the Edison and Weston machines. In a certain 100 incandescent light compound-wound machine of 100 volts, in which the distance between two pole piece projections, was about 14 per cent. of the whole circumference, the sparking was almost completely avoided, and the brushes required no adjusting for different loads ; it was impossible to see any increase of sparking when the whole load of 100 lamps was suddenly cut out or put into circuit. This shows the importance of allowing sufficient space between the ends of the pole piece projections.

(*To be continued.*)

ELECTRIC ILLUMINATION OF LIGHTHOUSES.[1]

BY DR. J. HOPKINSON.

The employment of the electric arc as a source of light for lighthouses has received attention for many years, but no apology is needed for returning to the subject, as the rapid development of electric apparatus brought about by the use of the electric light for other purposes, and the perfecting of new forms of motive power continually introduce new aspects of the question. An elaborate experimental inquiry has recently been conducted by the Trinity House concerning the relative advantages of electricity, oil, and gas as lighthouse illuminants, the actual experiments being addressed mainly to a comparison of the results obtainable in a practical shape by each illuminant *in its maximum development*, and it was conclusively proved that whether in thick weather or in clear the most powerful light at a distance and the most penetrating in fog could be exhibited from the electric arc. A further inference was drawn from a consideration of estimates of cost of the three systems, viz., that the electric light was necessarily costly and could only be economical when enormous power was needed. The latter inference is no doubt valid so far as the particular electrical and mechanical appliances considered by the Trinity House committee are concerned. The question may, however, be looked at from another point of view : given a limited permissible outlay and a limited annual charge for attendance and material, what can be done for the mariner by the aid of electricity?

Let us first see what are the intrinsic advantages of the electric arc. They all lie in great power in exceedingly small compass. The effect of the small size of the arc light upon the power of the light when used with optical apparatus has been often pointed out, and the accuracy with which positions of danger can be marked by colored sectors is also familiar to engineers. Less consideration has been given to the fact that it is undesirable to make the brightness of the light at any distance unnecessarily great, as excessive brilliancy dazzles the eye. It is a desideratum then whilst directing as powerful a beam as possible to the distant sea to avoid throwing more than a moderate illumination on the nearer sea. It is possible to realize this desideratum far more effectually with a small source of light like the electric arc than with any other illuminant, but with the exception of one lighthouse, so far as I know, it has been very partially attempted, the reason being a fear that the proper position of the arc could not be maintained. Almost the only complaint made by the mariner of existing electric lighthouses is that at a moderate distance they are dazzling. This is solely due to the fact that too much light is directed to the sea, or which comes to the same thing for this purpose, the beam directed to the horizon has, in order to cover any possible error of position of the arc, too much divergence imparted to it. Owing to improvements in lamps and carbons it is now safe to concentrate the light much more closely upon the horizon with the double advantage of greater power where the light is wanted, and moderated power where excessive power is injurious. This view is fully confirmed by the experience of the two most powerful lighthouses yet erected, otherwise than by way of experiment. Macquarie, in New South Wales, and Tino, in Italy, both constructed by Messrs. Chance Brothers & Co. The former is a first order optical apparatus, focal distance 92 cms., and although the concentration on the horizon is greater than in any previous lighthouse, complaints have been made that the light is too bright at short range.

Tino is a second order, 70 cms. focus, and the principle of strictly limiting the divergence and giving a smaller proportion of the whole light to the nearer sea is carried much further. The result is that in clear weather the apparent brightness of the light as seen from the sea increases with the distance until a distance of 8 or 10 miles is attained when full power is reached. By means of the simple optical appliances provided, there has never been any difficulty in keeping the source of light accurately at the focus. Experience then shows that a specially advantageous distribution of light between the nearer and more distant sea may be obtained with the electric light, provided a large and suitable optical apparatus is used. Distinction of lights apart, the true measure of efficiency of a lighthouse may be said to be the fewness of the occasions at which it fails to be visible at its advertised distance, subject to the condition that at no distance shall its brightness be an annoyance. This is attained by greater optical concentration towards the horizon with limited illumination of the sea together with the power of widely varying the intensity of the source of light, conditions which can be

1. Read before the British Association, September 6th, 1886.

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better realized with the electric arc than with any other source. The electric light possessing the advantages named, it is its supposed great cost which bars its introduction in many lighthouses.

Why, then, should the electric light be so excessively costly in a lighthouse for any but the very greatest powers, such as are only worth providing for a few important landfalls?

The great cost both of first outlay and maintenance appears to arise almost entirely from the fact that the machinery is arranged to supply on each and every night, however clear, an unnecessary amount of power, and consequently the heavy machinery always used is remote from the lantern, and it is necessary that two men shall always be on duty, one in the lantern, another with the machinery. Further, the dynamo machinery selected has been of a costly and cumbrous description. The essentials for a cheap electric lighthouse are, that for ordinary states of the atmosphere there shall be provided a plant under the easy control of the lightkeeper himself, and which shall be precisely adapted to produce that amount of light which is wanted in ordinary states of the atmosphere; but for thick weather there shall be provided a much more powerful engine and dynamo, available also as a reserve, in case the smaller machinery from any cause breaks down. The occasional machinery may be more remote from the lantern, as it is a small matter to require a second man to work on the comparatively rare occasions when the maximum power is needed. A small gas engine and dynamo machine can be placed without any crowding in the room immediately below the lantern, and arrangements can be made whereby the lightkeeper, whether he is in the lantern or in the engine room, can ascertain at a glance whether the arc is in its proper position with an error of less than one millimetre. The attendance on the lamp, rotating apparatus of the lens (if a revolving light), engine and dynamo would be easy, when the whole is brought together so as to be under observation at once; in fact, the gas engine, dynamo and lamp constitute together a gas burner which, though consisting of many parts, is automatic throughout, and when at work requires nothing but the constant presence of a custodian, exactly as a gas lamp in a lighthouse requires a custodian as a guarantee against failure. The same end, viz., concentration of the whole mechanical and electrical apparatus under one pair of eyes, could be attained, of course, in other ways, accumulators could be used, or a petroleum engine, but in order to give definitions and afford facilities for criticism, the better course will be to describe a suitable machinery, state what it will do, what attendance it will require, and what it will cost.

I propose, then, for an electric lighthouse, where small outlay is essential, the following:—A Dowson gas producing apparatus and gas holder, the generator and superheater being in duplicate, each capable of making 1,200 feet of gas per hour, the gas holder having a capacity of 3,000 cubic feet.

An eight horse nominal Otto gas engine and series-wound dynamo machine, placed in a room near the base of the tower and copper conductors to the lantern. The dynamo having magnet coils divided into sections so as to supply a small current when required.

A one horse nominal Otto gas engine and dynamo machine, placed in the room immediately beneath the lantern floor, with gas pipe from the gas holder, one spare armature. Current and potential galvanometers and switches. Three electric lamps to receive either carbons of 25 mm. or any lesser size with complete adjustments for accurate focusing. The positive carbon below. One paraffin lamp as a stand-by. An optical apparatus of the second order, 70 cms. focal distance, extending from 29° below the horizon to 80° above. The cost of this apparatus would depend upon the character of the light it was intended to exhibit. To fix ideas, let it be assumed that the light is to be a half minute revolving light showing all round the lighthouse. There could then be supplied a 16 sided apparatus, with pedestal and revolving machinery. Provision would be made in the optical apparatus for giving the horizontal and vertical divergence desired by the same methods successfully used in the lighthouses of Macquarie and Tino. Two focusing prisms would be fixed to form magnified images of the arc on pieces of obscured glass let into the pedestal floor so that the keeper, whether in the lantern or in the engine room, can see at a glance the state of the arc, and observe whether it is of proper length with the carbons in line, whether it is exactly at the right height and in the centre of the apparatus. An error of 1 mm. would be glaringly apparent, and call for immediate adjustment, although its effect would be only a displacement of the beam five minutes of angle.

The lantern would be 10 feet diameter, with bent plate glass The cost of the whole described would be materially less than £3,400, the cost of a first order light and lantern with oil lamps and large burners.

Let us now see what result would be obtained.

In fine weather, the small engine would be used. Its effective power on the brake is fully 1½ h. p.; from this 1½ h. p. the dynamo machine produces considerably over 800 watts, say 800 watts in the arc itself, or 20 amperes through a fairly long arc of 40 volts. Of course the value of this in candles depends upon the color in which it is measured, and the direction in relation to the axis of the carbons. In red light the mean over the sphere would certainly exceed 1,200 candles. In clear weather, or in slight haze or rain, the beam of this light through the lenses would be much more powerful at the horizon and on the distant sea than any single focus light in oil or gas, or at least would be fairly comparable with anything yet exhibited with oil or gas, whether triform or quadriform. But on the nearer sea the illumination would be reduced, so that no annoyance would be caused by dazzling flashes. In really thick weather, or indeed any weather when there was a doubt as to the visibility at the horizon of the lower power, the large engine would be used under the superintendence of the second keeper. This engine will give 10 h. p. on the brake, and there is no difficulty in obtaining 85 per cent. of this as useful electrical energy outside the machine, that is 6,340 watts. From this deduct 10 per cent. for the leads and the lamps and for steadying the arc, leaving 5,710 watts in the arc itself, or 114 amperes, with a difference of potential of 50 volts. Having regard to the fact that the optical apparatus here proposed acts upon a larger portion of the sphere than that used upon the South Foreland experiments, that the vertical divergence is less, and that the potential difference is greater, and the current continuous, although less in quantity, we may safely assume that the power of the resulting beam would not be inferior; indeed, the maximum number of watts actually developed in the arc in the lantern in the South Foreland experiments must have been materially less than $175 \times 40 = 7{,}000$ watts. It hence follows from the South Foreland experiments that in any fog whatever, the flashes would penetrate farther than those of any existing gas or oil light. The increased size of crater compared with that produced by the current of 20 amperes will give increased vertical divergence, and so cause the maximum illumination to be attained at a less distance from the lighthouse. The attendance of two men would suffice for all the duties of the lighthouse, because under ordinary circumstances one only need be on duty, excepting whilst gas is being made. The usual course would be, that with the exception of from two to three hours at the beginning of the night, the gas producer would be damped down, and when the small engine was at work the supply be taken from the gas holder. Consider the case of a long night of 15 hours. Immediately before lighting up the producer would be put to work and would require occasional attention from one keeper, but not his continual presence. For the first three hours of the night the engine would be using

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between 230 and 240 cubic feet of gas per hour, and the producer supplying between 1,200 and 1,300 feet, so that at the end of three hours there would be a store of 3,000 cubic feet, more than sufficient for the night, unless thick weather comes on, so that after three hours one keeper only would be on duty at a time, and he would always be in attendance on the light. In event of fog the keeper on duty would ring up his mate, who would start the larger engine and set the producer to work, and remain in attendance on engine and producer so long as the weather continued thick. A staff of two is adequate at all times, but it is true that more work would have to be done, both by day and night, about two hours in gas making, and perhaps one hour in additional, cleaning of machinery. It would be a question of expediency depending on the amount of thick weather to be provided for, whether a third man should be engaged, or additional pay be given to two men, for the additional work demanded from them; adopting the latter course, the extra attendance would be covered by about £35 a year, with an extra allowance when full power is in use.

The consumption of coal would be four pounds per hour of lighting, of water about half a gallon, of carbon about four inches per hour allowing for ends wasted. Comparing with an ordinary first order light, illuminated with paraffin, the account for lower power would stand somewhat thus:—

Credit.—Oil and wicks and glass chimneys saved, an expense varying with time and place but not less than, annually		£85	0	0
Debit.—Coal, 9 tons at 25s		£11	5	0
	Wages	30	0	0
	Oil and waste	6	0	0
	Carbons, 1,460 ft. at £10 per 1,000 ft.	14	12	0
	Extra repairs and contingencies	15	0	0
		£76	17	0

Which suffices to show that the charges would not differ materially from an oil light. The substantial advantage resulting would be that at a trifling cost per hour there is available at any moment a light of the greatest penetrative power.

Various objections may be taken to the arrangement here proposed and collateral points be raised, and it may be convenient to anticipate some of them.

A Dowson gas plant is unsuitable to a lighthouse built upon a rock offering no space beyond that occupied by the tower. True; until there is a paraffin engine burning oils as safe as the oils now used in lighthouse lamps, it is probable that the electric light will be excluded from such stations.

Gas engines and dynamos require a different training of the attendants from that which they have acquired with lamps for oil. Again true, but it is also true that starting with fresh men it would be as easy to teach them to manage the electric plant as the highly developed burner now used. Still no one interested would desire to see the electric light introduced into any service unless the keepers were intelligent and well trained and the supervision vigilant. Indeed, the electric light should be introduced gradually into lighthouses, though not so gradually as has been the case, giving time for the lightkeepers and inspectors to gain the necessary experience.

The first object of this communication is merely to prove that the minimum cost of an electric lighthouse is not *necessarily* greater than that of an ordinary oil light.

The maximum power would not be available if the eight horse engine and dynamo from any cause failed. The engine and dynamo could, of course, be duplicated at moderate cost, about £400, but this appears hardly necessary as the small engine, though of vastly less power, is still available. The purpose of the larger light is to reduce the number of occasions on which the light ceases to be visible at a stated distance, let us say to reduce it from 50 occasions per annum to 10. If on some one occasion this were not accomplished, the mischief would be the same as if on that one occasion the atmosphere had been a little thicker. The large engine is a complete stand-by for the small one.

A question well worthy of discussion is this:—in thick weather, is it desirable to direct the maximum illumination on to the nearer sea instead of the horizon? The correct answer to this question will undoubtedly depend upon the particular circumstances of each lighthouse, upon the height of the focus upon the sea and upon whether the light is for the guidance of the maritime traffic and protecting an extensive reach of coast, or whether it is primarily intended to mark some point of danger such as the Wolf Rock or the Eddystone. The presumption is in most cases against dipping the light; it implies robbing the distant sea; the keeper has to exercise his discretion from the appearance of the atmosphere in his vicinity or in particular directions, and to decide whether it is impossible that the light is reaching its advertised range; if he judges wrongly he may restrict the range of his light when it is unnecessary to do so. Some guidance may be obtained from the following considerations. With a second order light, and a continuous current of 114 amperes, practically maximum illumination will extend over a vertical angle of about 20′, and over a greater angle the illumination is not much less, we may therefore assume that at 16 below the horizon the illumination is as great as in the direction of the horizon, whatever efforts are made to concentrate on the horizon. If the focus be 100 feet above the water, the sea horizon is distant 11.6 nautical miles, and the range from a ship's deck about 15 nautical miles, but a ray dipping 10′ below the horizon will strike the sea at only 3.2 nautical miles from the lighthouse; if the focus were so changed that the light usually going to the horizon would dip 10′ below the horizon, the light which would usually strike the sea at 3.2 miles would strike that surface at two miles distant from the tower.

Probably the wisest solution is to duplicate the larger engine and dynamo, and in actual fog to use both engines and dynamos, and both gas producers. The resultant of 220 amperes not only has the effect of more than doubling the power, but also of increasing to a material extent the vertical divergence.

In conclusion, I would repeat the points I seek to establish. An electric light need cost no more either in first outlay or annual charges than a first order oil lamp of ordinary construction; economy can be secured by concentrating the machinery used in ordinary weather, *i. e.*, by bringing the engine and dynamo into proximity with the arc; and it is a radical mistake to reduce the capital outlay by reducing the focal distance of the optical apparatus.

THE DURATION OF A LIGHTNING FLASH.

Some curious information has been given lately on this subject. Mr. A. S. Barker photographed outside objects, on an excessively dark night, by the light of lightning alone. The wind was strong and the interesting feature was distinctly brought out, when the plates were developed, that the foliage had perceptibly moved during the exposure. The flash must therefore have a measureable interval, probably decidedly longer than the thousandth or ten-thousandth of a second, as got by Wheatstone. His method was of the same nature but the eye was employed as receiving instrument. By using a photographic sensitive plate instead of the eye, a decided improvement is introduced. The problem is a pretty one and deserves further study, and we commend it to skilled photographers. In actual experiment the photograph should be taken of some object, such as a rotating wheel, of which the velocity is great and uniform.—*Meteorological Journal.*

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EXPERIMENTS ON THE MELTING PLATINUM STANDARD OF LIGHT.[1]

BY CHARLES R. CROSS.

NOTWITHSTANDING the fact that the amount of light emitted normally by a square centimetre of platinum at its point of solidification has been adopted as a standard both by the International Electrical Conference and by the United States National Conference of Electricians, but very few experiments have been made to determine whether it can be made reliable and capable of practical use. An approach toward giving the method a practical form was made by W. Siemens,[2] who proposed to substitute the light emitted by a given area of platinum at its melting point instead of at its point of solidification, and suggested a means by which with this modification the standard could readily be utilized.

The following experiments resulted from a conference of a portion of the committee on standards of light appointed at the Electrical Conference at Philadelphia in 1884.[3] They had for their object the ascertaining of a single fact, viz., the amount of the average deviation which would arise in a series of measurements of the light emitted by a strip or wire of platinum of given surface when at the melting point.

A few preliminary experiments were made by the writer, in which a measured length of fine platinum wire, four one-thousandths of an inch in diameter, was placed at one end of the bar of a Bunsen photometer, with a gas jet shining through a limited aperture at the other end. A current from a small hand Gramme machine was carried through the wire, which was made to glow more and more brilliantly by increasing the speed of the machine. Following the method of Siemens, the greased disc of the photometer was moved farther and farther from the incandescent platinum, so as to keep the disc uniformly illuminated, until finally melting occurred. The last reading of the position of the disc gave the illuminating power of the wire at melting. An unexpected constancy in the results was found, so that it seemed worth while to make a longer series of such observations, which was done in the following manner. At one end of the bar of a greased disc photometer 200 centimetres (78.74 inches) long was placed a circular aperture, through which shone the light of an Argand gas burner. A platinum wire lamp was constructed, in which a given length of wire was stretched between two fixed knife edges, and held by clips, thus allowing of speedy adjustment of the wire. The disc used was furnished with two mirrors inclined at 45° in the usual manner, and it was always placed so that the two sides as seen by reflection appeared alike,—a method of measuring much more satisfactory than the one commonly employed with the Bunsen photometer. The length of wire used was measured between the edges when cold, and allowed to expand freely. An attempt was made to use a slit of given length in front of a longer wire, which was abandoned owing to errors arising from inequality in the length of that portion of the wire whose light passed through the slit when the wire expanded. The use of a small weight stretching the wire tight, as suggested by Prof. Pickering and employed by him in a small lamp, presents some advantages, but was discarded from fear of elongating the wire and so causing it to break before complete fusion was reached. Melting was brought about by the use of a slide resistance of german-silver wire in circuit with the platinum wire and a dynamo machine. The variable resistance of the slide was lessened until the platinum wire melted, the photometer disc being, meanwhile, moved repeatedly, its final reading giving the light emitted by the platinum in terms of the light emitted by the aperture opposite.

1. Read at a Meeting of the American Academy of Arts and Sciences, June 16, 1886.
2. Wied. Ann., 1884, vol. xxii, p. 304.
3. Messrs. J. Trowbridge, E. C. Pickering, and C. R. Cross.

No attempt has been made in these experiments to determine the absolute illuminating power of the wire, but only to ascertain whether ordinary commercial platinum wire has any practical value for use as a primary or a secondary standard.

Two different sizes of wire were used, whose diameters were .004 inches and .006 inches respectively. Wire from two different makers was also used, ordinary wire drawn without special care being taken because of its availability. The length used was always the same when cold, viz., two inches. A very large number of measurements were made, chiefly by Messrs. F. H. Crane and H. E. H. Clifford, students in the laboratory, and careful and accurate observers.

Five sets of observations on successive fusions of wire were made by each observer, and the mean taken. The mean and the average deviation from the mean of a long series of such sets were then found. The tables give the results of the measurements. In all cases the distance between the opposite lights is 78.74 inch (200 cm.), and the diameter of the aperture in front of the gas flame 3/8 in. The recorded distances are measured from the aperture.

In order to give an idea of the degree of concordance of the separate individual readings, the following sets (table I.) are taken at random. The numbers given are the final positions of the disc, in each experiment, in inches.

TABLE I.

Diameter of wire = .004 in.

Observer *M.*	Observer *N.*
43.7	43.6
43.6	43.7
43.7	43.7
43.6	43.5
43.5	43.8
Mean 43.62	Mean 43.66

A change of 0.1 in. corresponds to an absolute change of 0.007 in illuminating power of opposite light = 1.1 per cent.

Diameter of wire = .006 in.

Observer *N.*	Observer *N.*
37.7	37.4
37.8	37.2
37.4	37.4
37.2	36.8
37.2	37.2
Mean 37.46	Mean 37.20

A change of 0.1 in. corresponds to an absolute change of 0.01 in illuminating power of opposite light = 1.0 per cent.

Table II. is given at length as indicating more clearly the variations among consecutive sets of measurements. I. P. denotes the illuminating power of the platinum wire in terms of that of the opposite light. The average deviation of I. P. is the change in this quantity produced by an increase in the scale reading equal to the average deviation in inches.

TABLE II.

Diameter of wire = .004 in. Sample A.

Averages of 5 experiments. Observer *M.*	Averages of 5 experiments. Observer *N.*
43.6	43.7
43.7	43.5
43.6	43.5
43.7	43.4
43.5	43.4
43.6	43.6
43.5	43.3
43.6	43.6
43.6	43.2
43.5	43.7
Mean 43.59	Mean 43.49
Average deviation .06 in.	Average deviation .13 in.
I. P. = .650.	I. P. = .657.
Average deviation I. P. = .004.	Average deviation I. P. = .009.

Tables III. and IV. give the means of the various sets of experiments. Column 1 shows the sample used; 2, the mean of the series taken; 3, the number of observations from which the mean is derived; 4, the observer; 5, the

illuminating power; 6, the average deviation in inches; and 7, the average deviation in terms of the illuminating power. It will be seen that the maximum average deviation in I. P. for the finer wire is 1.7 per cent., and for the coarser wire 1.6 per cent. of the total value.

TABLE III.
Diameter of wire — .004 in.

Sample.	Mean.	No. of obs.	Observer.	I. P.	Av. dev. inches.	Av. dev. I. P.
A	43.59	50	*M*	.650	.06	.004
A	43.49	50	*N*	.657	.13	.009
B	43.77	50	*N*	.638	.11	.007
B	43.70	50	*M*	.643	.16	.011
B	44.86	50	*N*	.570	.18	.010
A	45.16	50	*N*	.553	.12	.007
A	43.73	50	*N*	.641	.12	.007

TABLE IV.
Diameter of wire — .006 in.

Sample.	Mean.	No. of obs.	Observer.	I. P.	Av. dev. inches.	Av. dev. I. P.
A	35.37	20	*N*	1.504	0.15	.024
A	37.19	30	*N*	1.249	0.14	.019

In order to determine the possible accuracy of setting the photometer disc, several series of readings (table V.) were taken, in which two apertures through which a gas-flame shone were balanced against each other. These readings were taken with apertures of different sizes, in order to test the accuracy of setting in different parts of the scale; that is, for different relative brilliancies of the lights. Series 3 and 4 were taken so as to bring the disc in the same position as that which is occupied with the .004 in. and .006 in. platinum wire.

TABLE V.

Series.	No. of obs.	Mean.	I. P.	Av. dev. inches.	Av. dev. I. P.
1	50	31.35	2.286	.076	.019
2	50	31.40	2.273	.054	.012
3	50	43.92	0.628	.042	.008
4	50	36.48	1.342	.044	.005

It appears that the average deviation of the different readings when the opposite illuminated apertures were balanced against each other is, in general, considerably less than that of the readings with the melting wire. The maximum average deviation of I. P. is 0.8 per cent. of its total value; the minimum value is about half as great.

Marked differences in the illuminating power of the platinum wire of the same diameter, on different days, were observed, contrasting strongly with the uniformity of the results of successive measurements. This undoubtedly arose from changes in the quality, and hence in the illuminating power, of the gas, as the height of the flame was kept constant. In future experiments, I hope to obtain a more constant standard by using a moderator lamp with aperture, or else by employing the pentane burner.

A consideration of the results given in tables III. and IV. shows that the light emitted by a filament of commercial platinum at the melting point is quite constant in successive measurements, and it appears to present greater uniformity than many of our commercial standards. There is little doubt, moreover, that by the use of a wire longer, and perhaps of larger diameter, the results would be improved, as there would be less liability to error from the cooling of the ends of the wire by contact with the metal supports (an action, however, which can easily be removed altogether), and from accidental minute inequalities in the length of the wire used. It would also be desirable to use platinum of better quality than is usually found in commercial wire, and to have special care exercised in drawing to insure accurate cylindricity.

It is also evident that such a wire as I have used cannot, at best, be employed, except as a secondary standard, since the ratio of the luminosities of the two gauges of wire employed is not at all in the ratio of the projection of their surfaces.

Still further, a difficulty may arise in the use of a melting platinum wire or strip even as a secondary standard, from variations in the physical condition of the metal due to cracking, occluded gases, or other causes. No certain evidence of this was observed with the samples of wire employed, but I am not at all sure that it may not occur with different specimens of commercial wire. From a few preliminary experiments, of a series still in progress, it appears probable that successive heating and cooling, or continued heating of the wire even under ordinary atmospheric pressure, tend slightly to raise its point of fusion, an action which Edison has shown[4] to be carried to an extreme degree when continued heating in vacuo is employed. Thus, in one experiment, the wire was heated by the current and cooled from one to ten times, and then carried up to its melting point, photometric readings being taken, as in previous experiments, with the following results. The wire was .006 inches in diameter. Each value given is the mean of five measurements.

	Mean Reading.
Without reheating	37.65
Reheated once	37.42
" twice	37.42
" 3 times	37.62
" 4 "	37.26
" 5 "	37.06
" 10 "	37.26

The lesser readings indicate greater luminosity of the melting wire.

In another experiment, the wire in its ordinary condition melted when the reading (mean of 5 measurements) was 37.8 in. After annealing in a Bunsen flame, the mean reading at melting (for five experiments) was 37.2 in. After heating to a yellow heat by passing a current of electricity through it for half an hour, the reading at melting (mean of 23 measurements) was 36.9 in.

If further experiment should show conclusively that the light emitted by melting platinum is variable beyond narrow limits, it is clear that any photometric standard based on the luminosity of *melting* platinum will present no advantage over those standards now in ordinary use, unless specially prepared platinum, freed from gases and consolidated by Edison's process of heating in vacuo, is found to be available. Probably solidifying platinum, provided its point of solidification is sufficiently definite, would be free from this objection, although this can hardly be accepted without experimental proof.

ROGERS LABORATORY OF PHYSICS, June, 1886.

THE HEATING OF AERIAL CONDUCTORS BY ELECTRIC CURRENTS.

BY J. GILBERT WHITE, PH.D.

(Concluded.)

IN these experiments the wires were heated to barely the point of self luminosity in a dark chamber. At this high temperature (about 526° C.) radiation becomes an important factor in the loss of heat, and we should, therefore, not expect the absolute emissive power to vary so much as at the low temperatures at which the experiments of Prof. Forbes, Prof. Bottomley, and those given in the first part of this paper were made. In the following tables, the current required to raise the largest wire to the required

4. Proceedings of American Association, 1879, vol. xxviii. p. 173.

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temperature, was taken as the basis of calculation. If the absolute emissive powers of the wires remained constant, we would have $C : C' :: d^{\frac{3}{2}} : d'^{\frac{3}{2}}$ and $C' = C\left(\frac{d'}{d}\right)^{\frac{3}{2}}$. An inspection of the tables shows that in every case, except two, the observed current was more than the calculated, the divergence becoming larger as the diameters decreased. This is fully explained on the theory that the absolute emissive power of the smaller wires, was the larger, and hence, a greater current than calculated was required to bring them to the desired temperature.

COPPER WIRE.

Diam. of wire in mils.	Observed current in amperes.	A.
30	23,969	23,969
24	16,832	17,151
20	13,711	13,047
18	11,269	11,140
14	7,654	7,641
8	3,849	3,300

PLATINUM WIRE.

Diam. of wire in mils.	Observed current in amperes.	D.
33	13,461	13,461
20	6,841	5,140
18	5,785	4,389
14	4,739	3,010
11	3,337	2,097
8	2,536	1,300

SWEDISH WROUGHT IRON.

Diam. of wire in mils.	Observed current in amperes.	B.
60	18,579	18,579
40	10,785	10,113
20	4,283	3,575
10	1,718	1,437

GERMAN-SILVER WIRE.

Diam. of wires in mils.	Observed current in amperes.	C.
25	7,047	7,047
20	5,106	5,042
16	3,916	3,608
14	3,743	2,953
8	1,257	1,276

The experiments of Prof. Forbes and Mr. Preece, made under such different circumstances, afford no means for determining even approximately what is the variation of the absolute emissive power for different diameters.

Hence the experiments described, page 292, and the data of which are given, page 364, were undertaken.

By laying off the temperatures as ordinates and the diameters in mils as abscissa, a curve of temperature is obtained. Equation (21) transposed gives

$$T = \frac{C^2 a}{2 \pi r^3 J E - C^2 a \varphi}$$

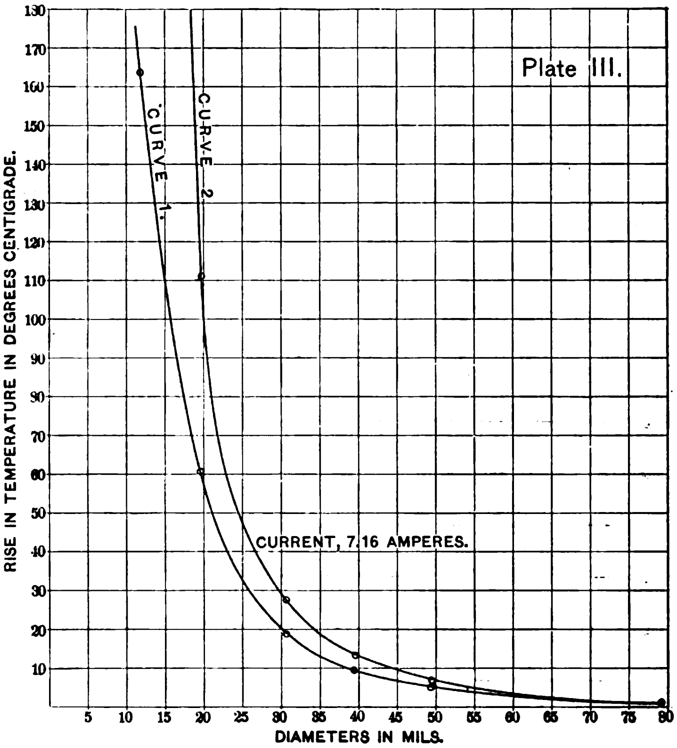
If T and r vary, the other factors remaining constant, we would have T varying nearly as $\frac{1}{r^3}$; since $C^2 a \varphi$ is small compared to $2 \pi r^3 J E$ for the C used in this case. If, however, E varies inversely with r then T will vary less rapidly than $\frac{1}{r^3}$; that is T will vary as one divided by a function of r, which function will be less than the cube. To get data for a curve showing this variation, calculations were made from table XXIV. By assuming that the temperature in a wire varies as the square of the current, which introduces no considerable error in this case, the temperature of the No. 20 wire and the one joined with it were reduced in every case to what they would be for a current of 7.16 amperes.

If the atmospheric conditions (draughts, etc.) had been constant, this should have given in each case, for the No. 20 wire an increase in temperature of 18.14°, the T actually observed for the No. 20 wire with a current of 7.16 amperes for which current all the values of T were calculated. But the actual observed T for the No. 20 wire varied somewhat from the T calculated as above; and to get them the same it was necessary to apply a correction to the observed T to counteract changing external conditions. It was assumed that the T for the wire coupled with the No. 20 wire would have to be corrected by the same percentage of its value as the No. 20, which could introduce no appreciable error, as the correction itself was in every case small.

The following table was made out as just indicated:

Current in amperes.	T of movable wire observed.	T of No. 20 wire observed.	T of No. 20 wire calculated for $C - 7.16$	T of movable wire calculated for $C - 7.16$.	Corrected T of movable wire for $C - 7.16$	Diam. of wire in mils.
17.03	10.33	116.1	20.59	1.83	1.63	78.9
13.61	21.4	65.9	18.30	5.94	5.89	49.1
14.18	40.98	80.23	20.41	10.41	9.29	39.8
7.16	.....	.....	.....	.....	18.14	30.8
7.16	61.34	18.14	18.14	61.34	61.34	19.4
3.84	47.89	5.29	18.35	166.18	164.29	11.96

Curve 1, plate III, was plotted from the table just above.



Curve 2 on the same plate was drawn by assuming that T varied as $\frac{1}{r^3}$. The divergence between the two lines is due, of course, to the increase in the absolute emissive power for the small wires.

But this shows, only after calculation, the variation of the emissive power. If, however, we use equation (21)

$$E = \frac{C^2 a (1 + \varphi T)}{2 \pi^2 r^3 J T}$$

we can calculate the values of E from the experimental data. By the method employed of using one wire as a basis of comparison, we have

$$\frac{C^2 a}{2 \pi^2 J}$$

common to the equations for both wires; hence we will have

$$E : E' :: \frac{1 + \varphi T}{r^3 T} : \frac{1 + \varphi T'}{r'^3 T'}$$

Having calculated E by equation (21) for the wire used as a standard, all the other values of E can be calculated from the proportion just given, then laying off the values of E as ordinates, and the corresponding diameters as abscissa, a curve is obtained representing directly the variation of E. If E were constant the line would be straight and run parallel to X.

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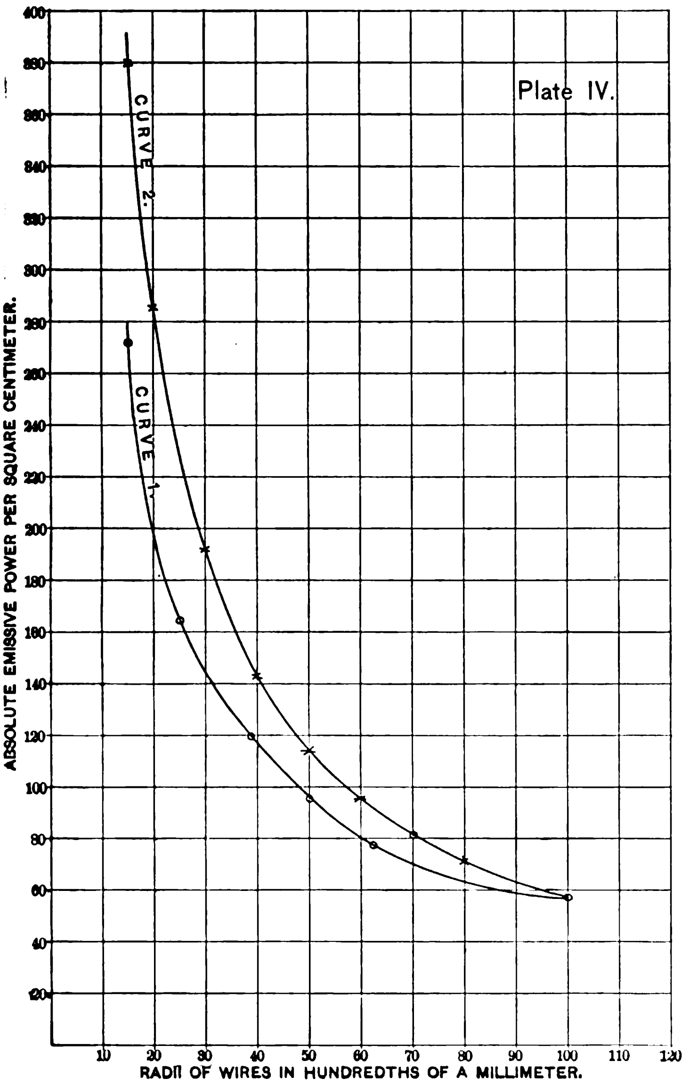
From table XXIV. we get the data for the following table, the values of E being obtained by calculating E for the No. 20 wire by equation (21), assuming a value for a of 1.652×10^{-6}, as given in Prof. Everett's "Units and Physical Constants." The other values of E were calculated from the proportion given on the preceding page.

No. of wire.	Radius of wire in centim's.	Current in amperes.	φ T	T	φ T′	T′	E. Absolute emissive power.
12	0.1002	17.03	45.03	116.1	4.01	10.33	0.000569
16	0.0625	13.61	25.57	65.9	8.31	21.40	0.000773
18	0.0505	14.18	31.13	80.23	15.88	40.93	0.000956
20	0.039	13.61	25.57	65.9			0.001193
24	0.0245	7.16	7.04	18.14	23.80	61.34	0.001653
28	0.015	3.84	2.05	5.29	18.58	47.89	0.002703

We have already quoted, as seeming very reasonable, the view of Prof. Forbes; that for small wires the loss of heat due to radiation is proportional to the diameter, but the loss due to convection is nearly constant. As the loss due to radiation is small compared to the loss due to convection, the total emissive power of unit length of the wire would be nearly constant.

But the total emissive power of unit length equal the absolute emissive power multiplied by a constant times the diameter.

If the total emissive power were constant, we would have $E\,r =$ constant: or $E = \frac{1}{r} \times$ constant, the equation of an hyperbola. Curve 2, plate IV., was drawn by assuming the preceding equation to be true, and starting



with the value of E given by curve 1 when r was 100. Curve I was plotted from the values of E, obtained by calculation as previously explained and given in the preceding table. The divergence between the two curves is just such as Prof. Forbes' view would lead us to expect.

Another problem of at least theoretical interest is, what is the relation of the excess of temperature at the centre of a bare wire over that at the surface, both being maintained at a temperature above that of the surrounding air by a uniform current.

A very good solution has been given by Mr. Perenyi, and we will again translate from *La Lumière Électrique* (Tome xiv., page 255). "It is in effect logical to admit the law already established, that there is a transmission of heat from one layer to the neighboring concentric layer, and that the temperature is more and more elevated as we approach the centre.

In order to simplify as much as possible the calculation, let us suppose that the co-efficient of specific resistance remains constant between T_0 and T_1, T_0 representing the excess of the temperature of the surface above the surrounding medium, and T_1 that of the central point. This hypothesis contains nothing exaggerated, since the co-efficient in question is modified but little by the temperature; though we may reach a still greater approximation by taking for a (specific resistance) a mean value corresponding to the mean of T_0 and T_1.

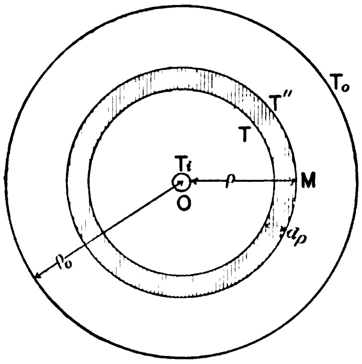


Fig. 2

This being understood, we may admit that the quantity of heat, $d\,H$, generated per second in a layer of infinitely small thickness dp, figure 2, is to the quantity of heat generated in the whole section in the same time, as the annular section is to the whole section, the conductor being considered of unit length. We then have

$$d\,H = H_0 \frac{2\,\pi\,p\,dp}{\pi\,p_0^2} = \frac{H_0^2\,p\,dp}{p_0^2} \qquad (h)$$

But the quantity of heat which traverses the circle M is equal to the sum from o to H of the elementary quantities $d\,H$; hence

$$H = H_0 \int_{-0}^{-p} \frac{2\,p\,dp}{p_0^2} = H_0\,\frac{p^2}{p_0^2} \qquad (i)$$

On the other hand, if we call T' the excess of temperature corresponding to the circle of radius p and T' that which corresponds to radius $p + dp$, the increase of temperature for an increase radius dp will be $-\,dT$, since the temperatures diminish as the radii increase.

The quantity of heat which traverses the ring M per second is directly proportional to the surface, to the co-efficient of conductivity K, and to the difference of temperature $-\,dT$, and inversely proportional to the thickness, dp. This quantity is, therefore, expressed by

$$H' = -\frac{K\,2\,\pi\,p\,d\,T}{d\,p} \qquad (j)$$

Having supposed the law established, it is evident that we should have $H = H'$, which gives by equalizing (i) and

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(*j*), $$-dT = \frac{H_0\, p\, dp}{2\, \pi\, K\, p_0^2}$$

Finally, integrating one part between the limits T_1 and T_0 and the other between o and p we get

$$T_1 = \frac{H_0}{4\, \pi\, K} + T_0,$$

an equation which may be written

$$T_1 = M \left(\frac{C}{d}\right)^2 + T_0,\ M \text{ being a constant.}$$

Or put in words, this formula means that the difference of temperature between the central point and the surface is (very nearly at least) directly proportional to the square of the current and inversely proportional to the square of the diameter.

A still more interesting, and, as we shall see, more practical problem is, what is the effect on the temperature of a wire of putting around it an insulating covering. Let T be the excess of temperature over surrounding air of a bare wire in the permanent state:

T' that of the same surface after the insulating covering has been put on;
T_1 that of outside of insulation;
E = absolute emissive power of bare wire;
E_1 = " " " " insulation;
r_2 = radius of bare wire;
r_1 = " " insulation;
K = conductivity of insulating material.

Considering first a very thin layer of insulation of thickness, dr, and radius, r, the surface of this layer for unit length is $2\, \pi\, r$; hence we may derive directly from the definition of conductivity, the heat conveyed through this layer

$$= H = \frac{K\, 2\, \pi\, r\, dT}{dr} \qquad (21)$$

dT being the difference of temperature of outside and inside of layer dr, transposing

$$\frac{dr}{r} = \frac{K\, 2\, \pi}{H}\, dT \qquad (22)$$

$$\int_{r_2}^{r_1} \frac{dr}{r} = \int_{T_1}^{T'} \frac{2\, \pi\, K}{H}\, dT$$

$$\log_e r_1 - \log_e r_2 = \frac{2\, \pi\, K}{H}\,(T' - T_1)$$

$$T' - T_1 = \frac{H}{2\, \pi\, K} \log_e \frac{r_1}{r_2}.\ T_1 = T' \frac{-H}{2\, \pi\, K} \log_e \frac{r_1}{r_2} \qquad (23)$$

But the heat which passes through the covering must equal that given off from the bare wire in the first case and from the insulation in the second, since we supposed the temperature to be in the permanent state in each case; and no change made in current or resistance. Therefore

$$H = 2\, \pi\, r_2\, E\ T = 2\, \pi\, r_1\, E_1\ T_1 \qquad (24)$$

Substituting in (23):

$$T_1 = T' - \frac{2\, \pi\, r_1\, E_1\, T_1}{2\, \pi\, K} \log_e \frac{r_1}{r_2} \qquad (25)$$

This shows us that whatever the current the ratio of T_1 to T' should be constant, since we may write

$$\frac{T_1}{T'} = \frac{1}{1 + \frac{r_1\, E_1}{K} \log_e \frac{r_1}{r_2}} \therefore \frac{T}{T'} = \frac{r_1\, E_1}{r_2\, E\left(1 + \frac{r_1\, E_1}{K} \log_e \frac{r_1}{r_2}\right)} \qquad (26)$$

Of course this equation is not exactly correct since the resistance will change with the change of temperature; but, since the resistance changes in proportion to the temperature, the corrections to be added to T_1 T' will have nearly the same ratios as themselves, and the ratio will not be appreciably changed. The agreement of this result with the result of the foregoing experiments is given below.

T' and T were read from the cross-section paper for currents taken at random.

T	T′	T/T′	T	T′	T/T′
15.2	7.9	1.92	35.7	19.2	1.86
18.8	9.8	1.92	40.2	21.6	1.87
21.8	11.3	1.90	50.0	26.3	1.90
28.0	14.9	1.88	61.5	31.8	1.93
32.1	16.8	1.91	82.7	42.8	1.93
Average of ten values.................. ...1.902					

Equation (26) might be used to calculate T' from T, or *vice versa;* but the constants K, E, and E_1 are so little known that we must wait further experiments before the equation will be of much use in this way; but still it shows some useful facts. If in this equation

$$K = o,\ T' = \infty, \text{ but if } K = \infty:\ T' = \frac{E\, r_2\, T}{E_1\, r_1};$$

or T' can never be less than

$$\frac{E\, r_2\, T}{E_1\, r_1}$$

Moreover, an increase in K causes a decrease in T', hence in the permanent state, as well as before that state is reached, an insulation of high thermal conductivity is advantageous.

The specific heat of the insulation does not enter at all into this equation, and is, therefore, of consequence only for cases when the current does not flow for sufficiently long time to bring the conductor to its permanent state.

Equation (26) can also be used when some experiments have been made on wires of a particular kind, and we desire to find the ratio for other wires of the same kind; but to use the equation even in this way it will be necessary to first establish more fully than has been done the law of the variation of the absolute emissive power of a conductor with a variation of its diameter.

An inspection of equation (26) shows that when $r_1\, E_1 =$ or $> r_2\, E$, T (the temperature of the bare wire) will always be greater than T' (the temperature of the insulated wire); for $\frac{r_1\, E_1}{K} \log_e \frac{r_1}{r_2}$ will always have a positive value.

We should, therefore, expect to find the temperature of the insulated wire less than that of the bare wire. That such is the case is shown by all the experiments recorded in this paper.

To show more clearly this relation the following table has been made out from table xxv.

Kind of wire.	No. of wire.	$\frac{r_1}{r_2}$ — ratio of diam. of insulation to diam. of bare wire.	$\frac{T}{T'}$ — ratio of temp. of bare wire to temp. of insulated wire.	$\frac{r_1/r_2}{T/T'} = \frac{r_1\, T'}{r_2\, T}$
Underwriter's...	16	2.33	1.57	1.48
" ...	18	2.71	1.65	1.64
Silk wrapped....	16	1.04	1.26	0.826
Clark Co.'s.....	18	5.42	2.35	2.31
"	18	6.06	2.62	2.32
"	16	4.74	2.80	1.70
"	14	4.75	2.55	1.86
Office...........	12	1.74	1.52	1.14
"	16	2.16	1.55	1.40
"	18	2.46	1.84	1.34
"	20	2.92	1.81	1.61

This table and table xxv give some interesting results, and results which it is hoped may be of some use to those interested in the subject. Still these experiments were not sufficiently extensive and complete to enable us to calculate the constants involved in equation (26) nor to put on cross-section paper curves showing the variation of the permanent temperature with a variation of the thickness of its

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insulation, for the insulations used. It was hoped that a simple empirical formula might be derived which would readily admit of calculating the effect of any thickness of insulating coverings of the most common kinds.

But the law governing this variation is apparently so complex that a much more extensive set of experiments than those recorded in this paper will need to be made before such a formula, that will be assuredly accurate, can be derived. It is hoped that an opportunity for continuing and extending these experiments may ere long be found.

We are now in a position to discuss a problem which was logically the second part of problem I; that is the relation of the temperature of an insulated conductor and the time since the starting of an uniform current.

The heat developed is used to heat the wire, to heat the insulation, and to supply the loss of that given up to the surrounding medium.

The heat developed is, of course, as before, $\frac{C^2 R}{J}(1 + \varphi T)\, dt$; for a small time dt. The heat used in the wire equals weight × specific heat × rise in temperature $= \frac{\pi r^2}{g} h\, dT$.

Similarly, the heat used in the insulation is

$$\frac{\pi (r_1^2 - r_2^2)}{g_1} h\, k\, dt,$$

k being a constant which expresses the ratio of the increase of the rise in the temperature of the wire to the rise of temperature of the insulation.

That k is a constant has been shown by the proof that the ratio of T and T_1 is constant.

Finally, the heat lost equals $2 \pi r_1 E_1 T_1$. These values put in the form of an equation give

$$\frac{C^2 R}{J}(1 + \varphi T')\, dt = \frac{\pi r_2^2 h}{g} dT' + \frac{\pi (r_1^2 - r_2^2) \times h \times k \times dT}{g_1} + 2 \pi r_1 E_1 T_1 \qquad (27)$$

But from equation (26) we get

$$T_1 = \frac{T'}{1 + \frac{r_1 E_1}{K} \log_e \frac{r_1}{r_2}}$$ which substituted in (27) gives

$$\overbrace{\frac{C^2 R}{J}}^{H}(1 + \varphi T)\, dt = \overbrace{\frac{\pi r_2^2 h}{g}}^{M} dT + \overbrace{\frac{\pi (r_1^2 - r_2^2) h k}{g}}^{S} dT + \overbrace{\frac{2 \pi r_1 E_1}{1 + \frac{r_1 E_1}{K} \log_e \frac{r_1}{r_2}}}^{N} T\, dt$$

Representing the cumbersome coefficients by single letters we have $H(1 + \varphi T)\, dt = m\,(dT) + s\,(dT) + m\, T dt$ (28)

$$dt = \frac{(m + s)\, dT}{H(1 + \varphi T) - n\, T} = \frac{(m + s)}{H - (n - H\varphi)\, T} dT = \frac{v\, dT}{H - uT} \qquad (29)$$

putting $v = m + s$ and $u = (n - H\varphi)$.

$$\int_0^t dt = \int_0^T \frac{v\, dT}{H - uT}.\ t = -\frac{v}{u}\left(\log_e (H - uT) - \log_e H\right) \qquad (30)$$

$$t = -\frac{v}{u} \log_e \frac{(H - uT)}{H} \qquad (31)$$

$$\log_e \left(1 - \frac{uT}{H}\right) = \frac{-t\,u}{v} \qquad (32)$$

$$1 - \frac{uT}{H} = e^{\frac{-t\,u}{v}} \qquad (33)$$

$$T = \frac{H\left(1 - e^{\frac{-t\,u}{v}}\right)}{u} \qquad (34)$$

Equation (34) is similar in form to that derived for bare wire, page 35; and written out in full is

$$T = \frac{H}{\frac{2 \pi r_1 E_1}{1 + \frac{r_1 E_1}{K} \log_e \frac{r_1}{r_2}} - \varphi H} \left[1 - e^{-\frac{t \left(\frac{2 \pi r_1 E_1}{1 + \frac{r_1 E_1}{K} \log_e \frac{r_1}{r_2}} - \phi H \right)}{\frac{\pi r_2^2 h}{g} + \frac{\pi (r_1^2 - r^2) h k}{g_1}}} \right] \qquad (35)$$

an equation too complex for use even if we knew the values of the constants.

Probably the most useful of all the problems connected with this subject is that of the economical size of wire for a given current. Sir Wm. Thomson was the first to prove a theorem, since much quoted, that the most economical conductor is that in which the cost per annum of the energy wasted in heating the wire is just equal to the annual cost of interest on and depreciation in the value of the conductor.

Then letting $P =$ cost of an electrical horse-power per annum for the number of hours during which the plant is in use; $M =$ the cost of a length, l, of the conductor; and $p =$ percentage allowed for interest on and depreciation in value of conductor.

$$\text{Then } \frac{C^2 R}{J_1} P = p\, m. \quad C = \sqrt{\frac{J_1\, p\, m}{R\, P}} \qquad (36)$$

Now as R and M are both proportional to the length, a calculation for one length will apply to any other. M can be taken directly from the manufacturer's price list, R can be obtained in the same way or calculated, p can be assumed according to the judgment of the engineer for any locality, and P calculated for the same place.

P will vary with cost of motive power, labor, system employed, number of hours during which plant is run per year, and other circumstances, and will have to be calculated by the engineer putting in a plant.

Discussions on this subject and on the safe currents for various wires have been given by a number of persons, notably Prof. Forbes, Mr. Preece, Mr. W. Geipel and Mr. T. H. Blakesley. Tables also have been prepared by several of these gentlemen; but they have been principally for bare wires, and the safe currents have been calculated on the assumption that the absolute emissive power for different wires of the same material is constant. When this paper was begun it was hoped that sufficient data could be obtained for calculating tables which would include, besides the resistance, fall of potential per unit length, and economical current, the safe current for each size of bare wire and of wires covered with the most common insulations. It is now evident that more extensive experiments than time permitted of making must be completed before the safe current can be computed for all wires. Tables, giving much of the other data have been computed; although the cost of the insulation would make a difference in the economical currents for insulated wires. It is hoped that at some future time the necessary experiments may be made and these tables made out.

PHYSICAL LABORATORY OF THE CORNELL UNIVERSITY, June, 1885.

ON THE PROPORTIONING OF CONDUCTORS, IN A SYSTEM OF ELECTRICAL DISTRIBUTION, FOR A GIVEN FALL OF POTENTIAL.

BY WM. S. TURNER.

In all the applications of electricity which involve the transmission of power, the energy absorbed by the conductor is an important factor. The proportion which it bears to the whole electrical output depends upon the size of the conductor, and the determination of this, therefore, should receive careful attention at the hands of those dealing with problems of this kind. In electric lighting, and especially in incandescent lighting from central stations, does the

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accurate determination of the proper size of conductors become a matter of prime importance. For in a branching network of wires, dividing and sub-dividing from one central point, the current which is supplied to each lamp, and consequently the E. M. F. at its terminals, depends on the resistance of the conductor connecting it with the machine. This pressure at the lamps it is desirable to maintain not only constant but uniform throughout the system. Hence the resistance, and consequently the fall of potential to each lamp must be made the same; otherwise lamps on one part of the circuit will receive more current, and burn brighter, at the expense of lamps on other portions of the circuit. Hence we see the necessity of exact calculation of the proper size of wire for different parts of the system, in order that the distribution may be as perfect as possible, and the illumination of the lamps uniform throughout. The injurious consequences of unequal balancing are easily apparent wherever this has not been properly attended to, occasioning dissatisfaction and ill-will on the part of those who suffer from them.

One of the best methods of calculation which obtains in practice, some of which seem rather loose and unsatisfactory, is to take the product of the number of lamps by the distance in feet, and multiplying this by a constant supplied from a table of constants. This gives the circular millage of the conductor, from which the size is easily found. A different constant is required for each percentage loss of E. M. F., and the table is good for but one form of lamp. A change of lamps necessitates the use of another table; and in case lamps of different candle-power are used upon the same circuit only approximate results can be secured. What is wanted is a simple and accurate formula which will give the size directly from the electrical quantities involved; and which is applicable to problems in the transmission of power for other purposes, as well as for arc and incandescent lighting. Below is given a formula, with the method of its deduction, which fulfills these conditions, and which it is believed, will give satisfaction in every case. It has been thoroughly tested, and, although perhaps not entirely new, the writer believes nothing similar has appeared in any of the electrical journals.

Let $L =$ the length of the conductor, lead and return.
" $D^2 =$ the square of the diameter, or circular millage.
" $C =$ the current flowing, in amperes.
" $R =$ the resistance of the lamps, or motor, etc.
" $E =$ the E. M. F. of lamps, etc.
" $10.495 =$ the resistance of 1 foot by 1 mil of the conductor of 98% conductivity.
" $V =$ the percentage loss of E. M. F.

Since the resistance of a conductor 1 foot in length by 1 mil in diameter is 10.495 ohms, a length, L, of diameter, D, will have a resistance of $\frac{10.495\,L}{D^2}$. Now the fall of potential in any part of a circuit is proportional to the resistance. Hence the loss of E. M. F. in the conductor will be to the E. M. F. absorbed by the lamps as their respective resistances; or,

$$\frac{10.495\,L}{D^2} : R.$$

But the former is to be made V per cent. of the latter

$$\therefore \frac{10.495\,L}{D^2} = V\,R \qquad (1)$$

$$\text{whence } D^2 = \frac{10.495\,L}{V\,R} \qquad (2)$$

$$\text{or } D^2 = \frac{10.495\,L\,C}{V\,E} \qquad (3)$$

$$\text{and } L = \frac{D^2\,V\,E}{10.495\,C} \qquad (4)$$

The last expression gives the length of a conductor of a given diameter for a required fall of potential.

These simple formulæ are applicable to all cases in which it is desired to obtain the exact dimensions of a conductor for a given loss of E. M. F. As the equation shows, the size depends simply upon the relations of the electrical quantities involved, and does away with all arbitrary constants, the use of which, by those who do not understand their meaning or derivation, is a source of frequent error. All the quantities which enter into it are readily obtained, and the expression applies equally well to all kinds of lamps.

Thus, if it is required to find the size of a conductor which shall allow a loss of 3% while feeding a circuit of 40 Westinghouse lamps, 100 volts, 6 amperes, at a distance of 250 feet, we shall have, substituting in equation (2);

$$D^2 = \frac{10.495 \times 500}{.03 \times 4.16} = 42060 \text{ sq mils,}$$

which, on referring to a table of dimensions of copper wire is found to correspond to No. 6, B. W. G.

The formula applies with equal facility and accuracy to an Edison, or Weston, or any other form of lamp, and commends itself, by its simplicity, and adaptability to the varying conditions of actual practice, to all who would do thorough and efficient work in this department of electrical enterprise.

FALL RIVER, MASS., Sept. 18th, 1886.

THE PRINCIPLES OF SECONDARY BATTERY CONSTRUCTION.

II.

(Continued from page 342.)

PURSUING our investigations further, and experimenting upon various substances, we should find that the attractive influences that various metals have for the dissociated atoms vary in degree, that although the negative oxygen would be attracted to either copper or zinc, it would, when permitted to choose, show a decided preference for the zinc. For instance, if instead of placing the two oppositely electrified platinum plates in our electrolyte, we place two plates, one of copper and one of zinc, we should observe that the negatively charged atoms of oxygen would turn towards the zinc, deliver up to it their negative charges, the copper would also attract the oxygen atoms, but in a far less degree, and as long as the two plates are kept separate, very little chemical action would be noticed. Connecting the two plates by a conductor of electricity, the zinc plate which has received a greater negative charge transfers the negative electricity along the conductor and charges the copper plate so that it actually now repels the negative atoms of oxygen seeking it, and commences attracting the positively charged hydrogen. As long, therefore, as these actions go on between the plates, we shall have a continuous current in the connecting wire, negative charges passing from the zinc to the copper, and positive from the copper to the zinc.

We see, therefore, that although each radicle possesses a certain definite amount of electricity, which may differ in sign, it by no means explains why the dissociated oxygen radicle is more attracted to the zinc than to the copper, which agree in sign. We have to learn, then, that the union of each atom with another not only imparts a given charge of electricity, but also urges this charge forward with a definite amount of force. This definite amount of force is the measure of the attraction, and is what is called by chemists chemical affinity, and by electricians electromotive force. To break asunder the bonds that the atoms form, necessitates a certain definite quantity of electrical charge; but, furthermore, this charge must be driven forward with an electromotive force, at least equal to that evolved in the union of these atoms. Taking oxygen as our standard electronegative substance, in an electrolyte

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of dilute sulphuric acid we should find the metals would attract it in the order given below; in other words, we should find it far less work to undo a combination of copper and oxygen atoms, than a combination of zinc or potassium and oxygen,—*Potassium, sodium, zinc, iron, hydrogen, lead, copper, silver, platinum, carbon,*—OXYGEN STANDARD,—*Lead peroxide.* Potassium has a greater affinity for oxygen than zinc, and zinc again than copper. Thus, if we place a rod of zinc in a solution of sulphate of copper, it displaces the copper, throwing it down as a metal, and the zinc itself slowly dissolves, to form with the solution sulphate of zinc.

If we now go back again to our platinum plates, which we noticed were collecting positive and negative charges of electricity from the hydrogen and oxygen radicles which they attracted, and devise means whereby the plates remain coated with the gases, instead of allowing them to escape to the surface in bubbles, we should obtain what would be equivalent to our copper and zinc plates. The oxygenized platinum surface would be attracting the hydrogen atoms with their positive charges, just as the copper plate did, and the hydrogenized surface would act in similar fashion to the zinc in attracting the oxygen, and along a conducting wire connecting the two we should find an electric current, until the whole of the charges had been neutralized.

Planté devised these means by using lead plates as the electrodes, immersed in dilute sulphuric acid. The negative oxygen attracted to the positive lead plate united with it, forming a coating of peroxide of lead, which is insoluble in dilute sulphuric acid, the peroxide thus forming a permanent coating upon the lead plate. The hydrogen atoms seek the negative plate, and form what combination they can with it. In a short time, the entire surface of the positive lead plate becomes covered with a coating of peroxide of lead, which, as we can see from our table, is even more electronegative than our standard oxygen itself, and, as a consequence, the further atoms of oxygen that seek the positive lead plate are repelled, and rise to the surface as bubbles. It is easy to perceive, therefore, that any very lengthened period of charging does not add to the amount of oxygen fixed on the lead plate. If, now, we cut off our charging current, we find that we have obtained the exact equivalent of our copper zinc combination, the plate of peroxidized lead corresponding to the copper, and the hydrogenized plate to the zinc. Connecting these two plates by a conductor, a positive current will flow along it from the oxidized plate to the other, until the action of the current, which is manifestly tending to neutralize the gases, has reduced the plates to a condition of equilibrium. This condition, owing to the strong affinities displayed, is very quickly arrived at, and the return current does not last long. The coating of peroxide in the early stages is merely a thin superficial layer, speedily formed and as speedily reduced; and since in charging we have seen that as soon as the layer is complete no further, or perhaps very little, additional oxygen can be fixed, it was evidently necessary to devise a plan whereby the thickness of this layer could be increased, so that in charging the action commencing at the lead plate should take some appreciable time before the outer surface of the peroxide could be reached. Messrs. Gladstone and Tribe have shown very clearly how Planté's method succeeded in obtaining the result. They attribute it to what is unfortunately too well known to electricians, viz., local action. The peroxidized plate is, as we have observed, a compound one, consisting of a sheet of lead, with a layer of very finely divided peroxide in close contiguity with it; and, as already remarked, we know that lead has a far greater affinity for oxygen than lead peroxide has, and as a consequence it robs the peroxide of one of its atoms of oxygen, so that between what was the peroxide layer and the plate we find a layer of lead monoxide being formed, and at the same time the lead peroxide itself is being gradually reduced to lead monoxide. This monoxide is, however, different to the peroxide, being soluble in sulphuric acid, and is immediately converted into sulphate of lead. We see, therefore, by this action the lead plate is gradually eaten into, and the depth of the coating increased. Now, upon reversing, this sulphate is reduced to metallic lead deposited in a fine spongy condition, and the opposite plate is peroxidized. These reactions again take place on the peroxidized plate, and so the surface of each plate is gradually made more and more porous. These reversals are continued until the cell has obtained a serviceable capacity. The successive periods of repose are found necessary, in order that the local action (which is very slow after the first few moments owing to the film of sulphate, which is immediately formed between the layer of peroxide and the lead plate, being a bad conductor) should extend to greater depths, and thus widen the field of action.

The one fault with the Planté battery, indeed, almost the only one, is the very tedious and expensive process of "forming." Were it not for this, its high electromotive force, low resistance, large surfaces, with their finely adherent coatings of oxide freely bathed in electrolyte, would have placed it at once in the forefront of all the subsequent so-called improvements, of which we should doubtless never have heard. That difficulty existed, however, and when Faure, in 1880, conceived the method of constructing a secondary battery, in which the tedious process of "forming" was avoided, the idea was hailed with delight, and it was thought that the dawn of an electric millennium was at hand. Every householder in every city in Europe would have his own little box of "electric light," and the problem of the sub-division of the electric light would be solved. Faure, instead of allowing the electric current to arrange the coatings of oxide, painted his plates over with a preliminary coating of red lead, made into a paste with dilute sulphuric acid, thus mechanically reducing the time of formation from the months or even years required by Planté to about a week. But here every advantage ended; if the Planté had but one fault, the Faure had plenty. The red lead paste was, when exposed to the action of the current, converted into peroxide on the one plate, and reduced to plain spongy lead on the other; but this paste never formed a closely adherent coating, and always tended to fall away. It was found necessary, therefore, to press the paste against the plate by paper sheets, and to enclose the whole in felt bags, which separated plate from plate. The resistance of the cell was thus considerably increased; the active material was not freely exposed to the action of the electrolyte until the felt rotted, when the paste, gliding downwards, gradually collected at the bottom in a soft, oozy mud, which was found to detract very considerably from the storage capacity of the cell, if it did not altogether ruin it. Material after material was tried, but nothing was found to stand the electrolytic action combined with that of the acid. Asbestos fibre seemed to answer; but this did not prevent the active material sliding down towards the bottom of the bag, gradually leaving the plates bare.

Swan and Sellon almost simultaneously devised the method of making the lead plate its own bag, by arranging it in the form of a grid, all the interstices being filled with active material. This was a distinct step in advance, as the plates might now be freely exposed to the electrolyte, the resistance of the cell diminished considerably, and consequently its efficiency very much enhanced. Troubles, however, were by no means ended. The active material during charge expanded at a much more rapid rate than the lead envelope, so that it grew beyond the surface of the plate; in discharge it contracted, and worked itself loose in its little niche, and a non-conducting film of sulphate gradually forming itself between, almost completely separated it electrically from its leaden support. The plate thus got unequally acted upon, expanded more in one direction than another, and so a state of strain was set

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up which caused it to buckle, and ultimately completely distorted the plate. In addition to this, the buckling, sooner or later, made the two opposing plates touch, and thus all chance of storage was ended. The separating bands of india-rubber and gutta-percha did not prove of much avail, since they only prevented the buckling in their own immediate vicinity, and unless a band was provided at every quarter of an inch, it seemed impossible to prevent the peculiar freaks the lead plates would play. To meet this, a certain number of the squares of active material were removed, and india-rubber plugs, projecting about a quarter of an inch each side of the plate, inserted, so that every square inch should have at least one plug, to protect it from being interfered with by its opposite neighbor. This, although not an absolutely perfect remedy, appeared to give fairly good results; the buckling, except in the outside plates, was lessened, and by slightly altering the form of the interstices in the grid, the active material, though still working loose and not retaining its absolute electrical continuity with the lead, was prevented from falling away and dropping between the plates, where, meeting with any little excrescence on its downward path, it was liable to stay, and so short circuit the plates.

The improved cell thus consisted of a number of lead grids, the perforations of which were filled with lead oxides carefully pressed in, so that the grids become apparently flat plates. These plates, with their india-rubber plugs keeping them apart, were fixed in a receptacle containing dilute sulphuric acid. The number of plates employed, and their size, determined the amount of storage capacity the cell was intended to possess. The size of the receptacle depended again on the weight of the active material employed, since, as the reactions involved are chemical ones, it is manifestly necessary to provide space enough for the amount of electrolyte needed to effect these chemical combinations. In the early days the receptacles were far too small, and it was by no means unusual to find that the whole of the sulphuric acid had entered into combination with the lead oxides, leaving water only as electrolyte.

At this point it may not be amiss to discuss briefly the influence the strength of the electrolyte may have on the construction of the cell. It is very easily seen, that by increasing the strength of acid used, the size of the receptacle may be reduced, and all other things being equal, we should say that the best effect would be obtained when the acid strength was such that the greatest amount of beneficial chemical action would be permitted; and since we know that the resistance of dilute sulphuric acid varies between very wide limits, we should also be inclined to say that the best strength would be that at which the resistance is lowest. According to the writer's experiments, these two results are reached at very nearly the same point; and although Messrs. Gladstone and Tribe have pointed out that in the formation process a weaker strength is advisable, considerably better results are found if in after use the percentage of acid be largely increased. Pure water is a non-conductor; so, with our cell almost completely denuded of acid, we find it not only a difficult matter to pass a current through the cell, but the chemical reactions involved are, with very weak acid, of a totally different character to those obtained when the acid strength is great. These actions are of a very prejudicial nature, and hence the absolute necessity of having a sufficiency of electrolyte of suitable strength.

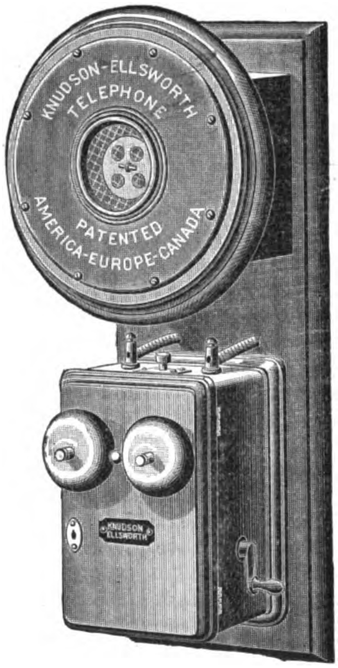
We notice also, that since the resistance of the electrolyte is very considerable as compared with the metallic resistance, it would be of advantage to bring the plates as near as possible to each other; but we must not forget, that as the size of the receptacle is governed by the weight of active material on the plates, so also is the distance between the plates. We must provide space sufficient for the proper combining proportion of acid which the chemical actions point out as being required. Thus not only do we gain in efficiency by using acid at the strength of least resistance, but we make a further gain by being able to bring the plates as near each other as is practically possible.—*Industries.*

A NEW ACOUSTIC TELEPHONE SYSTEM.

Acoustic telephones have long been used with fair efficiency for comparatively short distances. A good deal of attention and ingenuity have been bestowed upon their improvement of late. The old "lover's telegraph" is the type of them all; the improvements consisting in modifications of diaphragms and conductors chiefly.

The acoustic telephones of Messrs. Knudson and Ellsworth, and a special form of wire conductor devised by them, have points of excellence deserving attention. The diaphragm is the distinctive feature of their telephone. It is made of woven strips of a strong wood, several layers being cemented together, and put under pressure, forming practically, a solid piece, flexible, and impossible to split or crack, while at the same time it is extremely resonant.

Special features of the conductor employed by Messrs. Knudson and Ellsworth (and recently patented) seem not less important than the construction of the telephones.



In the use of acoustic telephones, disagreeable and troublesome disturbance of conversation has often been experienced, due to mechanical vibrations in the conductor. Such vibrations may be due to wind or other disturbing causes. The tendency of the stretched conductor—usually a single wire—under such disturbance, is to vibrate in nodal divisions, like a musical string, and thus produce disturbing noises, more or less musical, like the sound of an æolian harp, in the attached telephones. To obviate this disturbance, Messrs. Knudson and Ellsworth make their conductor of three or more wires of different sizes and degrees of hardness, twisted together and covered with a protecting material. This is done with a view of destroying the tendency exhibited by a stretched single wire, when disturbed, to vibrate in nodal sections, and is said to be entirely successful in eliminating the humming, so often heard in acoustic telephones.

The theory of Messrs. Knudson and Ellsworth is, that the several wires of their conductor, having different nodes of vibration, and not being so closely twisted together as to form substantially a single wire, their different rates of vibration neutralize each other in case of external

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disturbance, but in nowise interfere with the capacity of the conductor as a whole, to vibrate longitudinally with the motion of the diaphragm of the telephone.

We have had an opportunity of trying these telephones as used on short lines, and found them very effective.

Mr. Knudson tells us that at an intermediate point on a short line, a person holding the conductor between his teeth, can hear distinctly what is said at the terminals, the action being like that of the audiphone; and can even make himself understood at the terminals when speaking, though less satisfactorily than he can hear.

For some business, and many social purposes, such telephones would seem to have a considerable field of usefulness.

ON THE TREATMENT OF SECONDARY BATTERIES.[1]

BY BERNARD DRAKE, AND J. MARSHALL GORHAM.

THE possession of a reliable means of storing electrical power is now universally recognized. For electric lighting, whether temporary or permanent, whether domestic or public, it is almost an essential, for the commercial application of electricity to motive power it is a necessity.

The theory of secondary batteries or accumulators, by means of which this storage is attained, has already been so ably dealt with, and is, probably, so well known to all present, that it is unnecessary to enter into it in this short paper, the object of which is to bring to your notice some practical points of treatment which are essential, in order to render secondary batteries commercially reliable.

These points have been arrived at by experiments carried on by Mr. Gorham and myself, in the course of the manufacture of the batteries of the Electrical Power Storage Company.

The three main difficulties which we had to encounter were :

1. The destruction of the lead grid or conductor.
2. The buckling or warping of the plates.
3. The falling out of the active material.

These three failings, principally affecting the peroxide plates, militated seriously against the commercial success of accumulators, of which durability forms so important a factor.

We, therefore, carried out a large number of experiments, with a view to ascertain their various causes, and, by removing them, to render the secondary battery with which we had to do, as reliable for durability as it already was in other respects.

Here I may mention that these failings, although common, were by no means universal. For instance, the E. P. S. accumulators in the Bank of England have been in use more than 2½ years, and continue to give excellent results. That they do so confirms the conclusions to which experiment has led us.

We will take first :

1. The destruction of the lead grid or conductor. This was the most serious difficulty to face, as on it depended the life of the battery.

The prevalent idea was that it was due to overcharging ; that after the peroxide plate was fully charged any further charge caused an evolution of oxygen which rapidly destroyed the grid. We, therefore, proceeded to charge some cells without cessation in order to ascertain the exact amount of current which would entirely destroy the lead conductor, or grid. It was soon evident that the process was, at any rate, a slow one ; but the experiment was continued, until the full prescribed current had been passed through, for more than two months. At the end of that time it was found that the lead conductor was practically as sound as before charging ; the coating of fine peroxide formed on the surface was very thin ; there was no sign whatever of buckling, and, further, the specific gravity of the solution, when the cells were left in their then fully charged condition, remained absolutely unaltered.

The conclusion thence drawn was that the oxidization of the grid caused by charging only penetrated to a very limited depth, and then ceased entirely, and that the coating of fine peroxide formed actually protected the grid, not only from deterioration by overcharging, but also from local action hitherto supposed to be unavoidable.

It was then established that the life of the grids was not proportional to the amount of charging, *i.e.*, to the number of ampere-hours put into a cell. Was it due to the number taken out ? To ascertain this was the object of the next experiment.

For this purpose a battery was divided into two halves, one of which, A, was repeatedly run out, and the other, B, was never discharged beyond the point at which the electromotive force commenced to drop. This experiment also extended over a considerable time, but gave the instructive results that when exactly the same number of ampere-hours had been taken out of each half, the plates in the first half, A, showed signs of expansion or growing, whereas in those of the second half, B, no change could be detected.

The life of the grid then was also not dependent on the amount of ampere-hours taken out, or on the work done, but on the treatment of the plates, first as to charging up, and afterwards as to total or partial exhaustion. Further, it was satisfactorily proved that there was no necessity to employ a conductor of unoxidizable material, providing the simple precautions were taken :

1. To fully charge the cells.
2. To avoid discharging them entirely.

The second point to be considered is :

2. The buckling of the plates.

This had hitherto been attributed to two or three causes—charging too rapidly ; discharging too rapidly ; impurities in the acid or oxides employed.

Experiment soon showed that the real cause must be sought for elsewhere.

We found that the buckling was almost invariably accompanied by a hard, white enamel (sulphate of lead) on the face of the plates, and further, that where the extra cells in a battery had received more charging than the remainder, the plates in these cells were frequently quite free from sulphate, and the consequent tendency to buckle, while the rest of the battery had failed. This proved that the enameling could be prevented by charging, and was not due to impurities in the oxides or acid used ; further, that when the plates were free from sulphate there was no tendency to buckle.

Experiment also showed that in the case of the first use of cells, when the acid was first put in, the specific gravity dropped in spite of the charging, indicating the formation of sulphate ; by persevering in charging the sulphate disappeared, and with it the tendency to buckle. The conclusion was then that in order to avoid buckling of the peroxide plates, cells on their first use (whether new or after long disuse) should be charged incessantly until they are considerably overcharged. Hence the radical change in the instructions issued to users of the E. P. S. batteries. Whereas, hitherto, they had been specially cautioned against overcharging, they are now urgently required to overcharge new cells, and to charge incessantly.

3. The separation of the active material. In almost every case where this occurred the plugs of active material fell out of the plates in complete halves and in very hard condition ; and analysis showed that they contained an excess of sulphate, due, as before explained, to insufficient charging. On the other hand, in a few instances the active material was found to have become disintegrated and fallen off in a fine powder, and this was specially observable when on account of a leak in the receiving vessel and consequent frequent addition of water, the

[1] Read before the British Association, Sept. 4, 1886.

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solution had become extremely weak. In this case practically no sulphate was present, and the mass lost cohesiveness.

The conclusion is then that a certain proportion of sulphate in the material is necessary to bind it together, but that excess must be avoided. This due proportion once ascertained, the third difficulty is overcome for all the ordinary work of secondary batteries.

It should be mentioned, however, that there is a constant demand for an accumulator which can be discharged without injury at an abnormal rate for special purposes. Such rapid discharge results at present in the scaling off of the oxides and destruction of the plates, but as it causes the formation of sulphate, which is the binding not the disintegrating agent, the cause of the scaling, and, therefore its remedy, must be sought elsewhere. On this point discussion is invited.

I venture briefly to recapitulate the conclusions to which our experiments have led us.

1st. That the life of the leaden grids or conductors, and their freedom from buckling, are in no way dependent either on the amount of charging or discharging of the cells.

2nd. That cells on the occasion of their first use, and also after long intervals of idleness, should be very fully charged, and in the first case incessantly.

3rd. That they should never, under any circumstances, be entirely run out, and in fact should not be discharged below the point at which the electromotive force begins to drop perceptibly.

4th. That the coating of fine peroxide formed during charging is actually a protection to the plate against the injurious effect of overcharging, and against local action.

5th. That a certain small proportion of sulphate is necessary to give cohesiveness to the active material, but an excess of it causes the oxide to separate bodily from the conductor.

If the precautions here indicated be taken, we believe that the accumulators now made by the company with which we are connected, will answer every ordinary commercial requirement during a very considerable time, but an accumulater is not at present known which, without sacrificing capacity and efficiency, will stand the extraordinary rate of discharge sometimes demanded.

As we thought it might be of interest to give some reliable figures on the results which may be expected from cells as they are now made, we have, during the last few weeks, made very careful tests with some cells taken at random from stock, and worked in accordance with the practical requirements of an electric light installation.

It will be seen from the curve marked A, figure 1, which is the mean of six consecutive discharges, that the electromotive force is practically constant during a discharge of such duration as the cells would ordinarily be called upon to give, namely, nine hours—the fall of electromotive force during this period amounting to only .02 of a volt. When the cells were discharged for 4½ hours, left standing for a day, and then discharged for another 4½ hours, the result was exactly the same as when the discharge was continuous, both as regards electromotive force and efficiency. In fact, we were able to obtain a short time back from a similar cell, left fully charged for a month, an output of 380 ampere-hours.

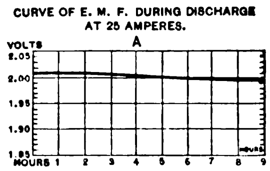

Fig. 1

The charging of the cells under test was always continued for about an hour after the gases commenced to be given off, so as to comply with the requirements of our working instructions, and to keep the plates in good order. This naturally reduced the efficiency or return both in ampere-hours and watt-hours; but in spite of this overcharging, the result of six consecutive charges and discharges gave an efficiency of 90 per cent. ampere-hours and 80 per cent. watt-hours.

Curve D, figure 3, shows the capacity of the cells in ampere-hours when discharged at 25 amperes rate, and is the mean of two continuous discharges. It will be noticed that with 10 per cent. drop of electromotive force the capacity is over 400 ampere-hours, and that the maximum output given in the lists of the company is reached with a drop of under 5 per cent. in electromotive force.

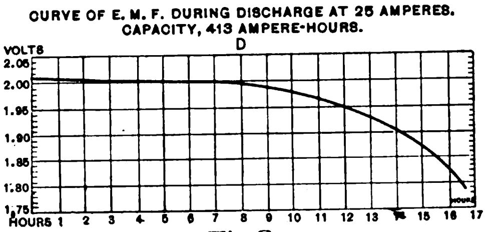

Fig. 3

The curve C, figure 2, shows the rise of electromotive force during the charge, the current being throughout kept constant at 22 amperes. It will be seen that at the commencement of the charge the electromotive force required was only 2.02 volts, that after 220 ampere-hours had been put in, representing about half the charge, the electromotive force had risen to 2.13, and that when the cells were giving off gases freely the electromotive force was as high as 2.53 volts. This curve will no doubt be of interest to those who manufacture dynamos for use with secondary batteries, as it shows clearly the range of electromotive force for which provision has to be made if the current is to be kept constant. In most instances, however, we arrange for a maximum electromotive force of 2.5 volts per cell to be charged, and allow the rate of charging to be diminished as the cells become full.

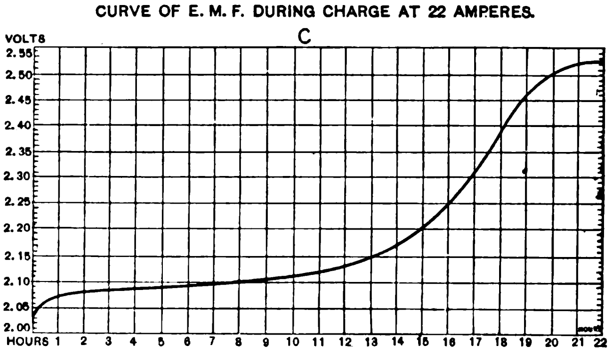

Fig. 2

The cells tested were of the 15 L type, and contained 7 peroxide plates weighing 36 lb. in all, and 8 of spongy lead weighing 33½ lb.

These plates are not made to give the maximum output from the minimum of weight, but the chief consideration is durability coupled with efficient working. They give a capacity of about 5 ampere-hours per pound of plate, which in the S type plates is increased to 6½ ampere-hours per pound for tramcar work; and where durability is of minor importance there is no difficulty in obtaining considerably higher results. The internal resistance of a single cell was measured during discharge and found to vary from .0012 ohm when the cells were fully charged, to .0026 ohm when discharged, to 10 per cent. drop of electromotive force.

This was tested by observation of the E. M. F., first on open circuit and afterwards discharging at a known rate; but owing to the tendency of the cells to rapidly recover their electromotive force when left partially discharged,

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it is somewhat difficult to get reliable results after the electromotive force has dropped to any extent.

We are convinced that the above figures are absolutely reliable, as the strictest precautions were observed by Mr. Butler, the head of our laboratory, in calibrating the instruments used and checking the results.

The current was measured by frequent readings from a Siemens ammeter, checked by a voltameter, the two being found to agree within 1 per cent.

The electromotive force was measured with a reflecting galvanometer calibrated by means of Clarke's standard cells and freshly made Daniell cell, the total resistance of the galvanometer circuit being 40,000 ohms.

UNDERGROUND WORK IN BROOKLYN.[1]

BY W. D. SARGENT.

The very rapid growth and accumulation of wires near our principal office in Brooklyn, compelled the consideration of the underground question, regardless of the newspaper hue and cry and compulsory legislation. Unfortunately for the credit of our good intentions, no work was done until after the passage of the present underground act, in May, 1884.

It may be noted, in passing, that the sentiment against poles and overhead wires seems to have been manufactured by newspapers and underground companies with an "axe to grind," evidence of which is our present extensive system of poles and wires erected without protest from property owners and citizens.

In the summer of 1884 it was decided to attempt to place some wires under the streets. Believing that such a complex system as ours could never be fully accommodated by wires laid permanently in the ground, we decided to lay a conduit comprising a series of ducts, permitting the introduction and withdrawal of wires and cables, thus providing space for future growth; for the withdrawal of defective cables and the substitution of others, as experience determines are the most suitable.

Up to this time, no cables or wires can be had whose durability has been sufficiently tested to warrant the faith to lay them permanently underground without any expectation of being able to reach them without tearing up the entire street. While the liability to damage when laid permanently underground, may be very remote, facilities for handling cables without opening the street are worth providing for on economical grounds. In many of the systems already laid, it is customary to box the cables in wood and fill in with asphaltum or cement. The same box can just as well be left empty and the cables drawn in and out without much greater expense, provided the wood can be made durable.

In looking up the durability of wood laid underground, in which we were very much aided by the commissioners of electrical subways, we found the most competent authorities agreed that the process of creosoting, when properly done, would preserve it indefinitely. Conduits of different materials, iron, cement, asphaltum, etc., were examined, but creosoted wood appeared to be the cheapest, and as durable as any. These considerations led to its final adoption for our conduit.

The form decided upon was a square box, sides, top and bottom one and one-half inch plank, subdivided into ducts, varying in number from 10 to 4, according to requirements —the divisions being made with one inch boards.

As the man-holes in the first work were not very frequent, we anticipated that friction and the consequent strain of drawing in long and heavy cables might be sufficient to injure them. With the intention of obviating this difficulty, the ducts were made three inches high by two wide, and rollers were placed permanently in the bottom of each duct, for the purpose of lessening friction. This we found to answer very satisfactorily.

In the season of 1885, the underground commissioners assumed direction, and at their suggestion the rollers were made into small carriages, consisting of two rollers below, one above, the cable resting on the upper roller, the intention being to withdraw the carriages after the cable was pulled in, and using them for successive cables. In the more extensive work which we have done in 1886, the man-holes becoming more frequent, we find that lengths of 1,000 feet or less may be readily drawn in, without injury to the cable, and without rollers or any anti-friction device. (The blue print drawing, which is here for the inspection of members interested, shows all the details, without further description.)

The general plan of distribution contemplated for the thirteen miles of conduit which will be completed this year, is to bring the cables out to poles, or on the house-tops, in bunches of 25, 50 and 100, and distributing as now through the air. This method of distribution has been permitted by our underground commissioners, pending the development of something better. We are not prepared to offer any plan for introducing individual wires into the buildings.

Preliminary to opening the streets, a map was made, showing the location of water, gas and sewer pipes, from information obtained from city departments and gas companies. This information proved to be as valuable as that of the pilot who knew every rock in the channel, and when the ship struck said, "There is one of them now;" and it was in this way that we came to know every pipe in the street, that is, as we struck them.

We think it is safe to say the obstructions in the streets of Brooklyn are less than in many others cities, even of smaller size. The character of the ground is sandy and usually easy digging, but frequently obstructed by large boulders, which require blasting to remove them. There is no ledge of rock in Brooklyn. The proper way in laying out a line for an underground conduit is to dig test holes over the route desired, thus locating all obstructions and digging trench accordingly. The depth of trench with us is usually thirty inches; but owing to service pipes for gas and water and occasional large mains, we have gone in some cases to a depth of seven feet.

As to the durability of our work, time alone will tell. The first half mile of our creosoted conduit will be down two years in November, and inspection just made before the writing of this paper shows no sign of decay in the timber, and the iron screws and nails are not corroded.

The objection usually made to this conduit is that it is not water-tight. This is true; nor did we attempt to make it so. The only damage that can result from water flowing through the duct is the accumulation of mud or silt, sufficient to clog them up. In the work already done, after two years' service, a recent examination at several points showed no deposit of any kind, and we are able to move the cables freely. In order to prevent the possibility of this trouble in the more extensive work now in progress, we have adopted the plan of pouring hot pitch or asphaltum over all the joints, sealing them up effectually.

Regarding the location of man-holes, these have heretofore been placed only at points of distribution and where obstructions rendered them necessary. The growth of the underground system will doubtless require man-holes at the junction of all streets.

The creosoted wood (North Carolina pine) is treated and furnished by an establishment in our own city, the price under our present contract being $41 per 1,000 feet, board measure, including mill work. The conduit is made up complete by our own workmen into sections of 16 feet, which are then carted to the trench, dropped in, joined up, and covers screwed on.

Special care is taken where sections join to make the ducts continuous and in line. In addition to pitching the

1. Read before The National Telephone Association at St. Louis, Sept. 8th.

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joints, the junction of sections is covered with felt and heavily pitched. The cost per foot of single duct laid in the trench and ready to fill in, based on the work already done, is six to ten cents per foot. The cost in detail is shown by statement open to the inspection of members.

Our first trench work was done by contract, the price being 30 cents per foot, 18 inches wide by 30 inches deep, with extras for rock work and additional depth.

Work done by contract has its disadvantages, principally on account of inability to control the work as thoroughly as is desirable. For this reason we decided to do the work ourselves this year, and it is probable the cost will be less. The advantage, however, is in the absolute control and thoroughness of the work. The ordinary Italian laborers are employed under suitable foremen.

We have made a contract with D. H. Dorsett for five miles of his asphaltum or concrete conduit, which is now well under way, but regarding which no figures can be given at present.

In cables we have used principally the lead pipe, covered, furnished by the Western Electric, Brooks, and Faraday. These are made up in fifties and hundreds, with wires twisted in pairs. The twisting in pairs is done to provide for perfect metallic circuits when they become necessary. During the time we are using grounded circuits the interference between the wires of a pair is greater than if not twisted, if they happen to be used simultaneously. The possibility of this is very remote, and we don't think it worth providing for.

One section of 4,500 feet, just laid by Brooks, is interspersed with braided tinsel, for the prevention of interference. No comparative tests have yet been made to determine its value. The balance of the cables are without any special device.

The first cables, drawn in in 1884, began to show trouble in about eight months, and the manufacturers were notified, their investigation finding the trouble in the terminals, except in one Brooks's cable, in which the lead pipe was found badly corroded. One section of 600 feet was withdrawn, in which we found a crack in the pipe at a wipe joint that had admitted moisture. New terminals were put on. The whole difficulty with the terminals is to get them moisture-tight. Within the last few months air and moisture-tight terminals have been furnished, which we believe will prevent future trouble.

The durability of lead pipe is a very important question. The corrosion of the Brooks's lead pipe has now reached one-eighth of an inch in depth, and the indications are that the whole pipe will be consumed. Opinions differ as to the cause of this corrosion. The product is undoubtedly carbonate of lead, and Prof. Plympton says it is caused by the action of water-gas, which collects in the ducts. Other authorities believe it is due to the vapor of acids in the creosoted woods. The pipe was made by Tatham Bros., of Philadelphia, and is said to be pure lead.

The Western Electric cables have a small percentage of tin, which was put in to stiffen the pipe; but it seems to serve another useful purpose, inasmuch as their cables laid alongside the Brooks show no sign of corrosion. It is fortunate that a remedy is so immediately indicated for what promises to be a serious evil.

Our greatest length of cable underground up to the present time has been 2,400 feet; interference is very slight, and retardation not perceptible. The trunk wires between New York and Brooklyn work through two miles of cable without serious difficulty, and we dont anticipate our troubles will begin until we get beyond that point. The longest cables laid this year are 4,500 feet, and tests show that we shall have no difficulty in working them. The insulation varies from 50 megohms to 500 per mile. Static capacity not measured.

We expect to be able to maintain our pole wires for a reasonable time to insure durability of cables, and to retain them entirely where the wires are less than 50. New poles will necessarily have to be put up to aid in distributing from the underground, and we are now putting up some for that purpose.

One of our underground commissioners is now in Europe, and in a letter from him, dated Milan, he writes as follows: "I have heard of no underground telephone wires since I left London. I am a little in doubt about a few in Berlin, but the rule is, 'mount them on the housetops.' The government can compel submission of the citizen, but awards him some compensation. Perhaps the most striking incident of the journey was finding a new line of telegraph poles in the streets of Antwerp; I have ordered a photograph of them. Preece says he never knew a case of failure of well-creosoted timber through decay."

This was written after the writer had been at Liverpool, London, Brussels, Antwerp, Cologne, Weisbaden, Heidleberg, Frankfort, Berlin, Munich, Lucerne, Milan. This seems to indicate that the problem for underground wires for a telephone system is quite as difficult a question there as it is here.

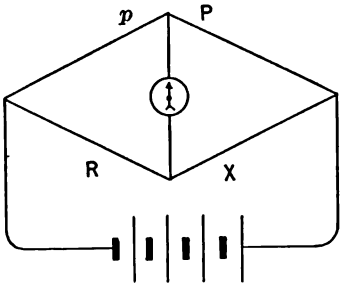
A NEW PROOF OF THE WHEATSTONE BRIDGE.

BY SIR DAVID SALOMONS.

(From the *Electrical Review*, London.)

The present proofs are somewhat complex, but the following is extremely simple and clear, and was devised for expressing diagrammatically the various uses to which the bridge may be put for daily work.

It may be assumed that the reader understands the use of the bridge in practice, and therefore it will be unnecessary to go into details, so that a general description will suffice. The bridge is generally drawn thus:—

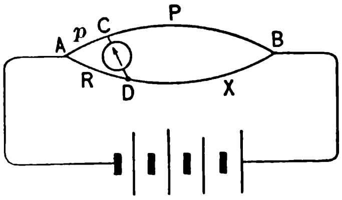


Where P and p = proportionals
R = variable known resistance
X = unknown resistance

then

$$\frac{P}{p} = \frac{X}{R} \text{ or } X = R\frac{P}{p}.$$

Now let us look at the bridge as nothing more than a *shunt*, and draw it thus:—



Here the current divides at A, and goes along two courses, each having any resistance equal or unequal to one another. Clearly the fall of potential between A and B on the upper or lower conductor must be the same, for two differences of potential between A and B cannot exist. Further, the fall along each of the conductors will be regular; hence a point can be found on each conductor which shall have the same difference of potential between each point and A. Call these points C and D, and join them

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with a galvanometer in the course. Call C A, p; and C B, P; D A, R; and D B, X; and let p, P, R and X have the same meanings as in the first figure. Here, however, C and D are movable points. Now move C and D along their own conductors until the galvanometer shows no deflection. At these points the potential must have fallen between A and C, and A and D to an equal extent, and between C and D there is equilibrium, and no current will flow through the galvanometer. When this is the case it is evident that

$$\frac{P}{p} = \frac{X}{R} \text{ or } X = R\frac{P}{p}.$$

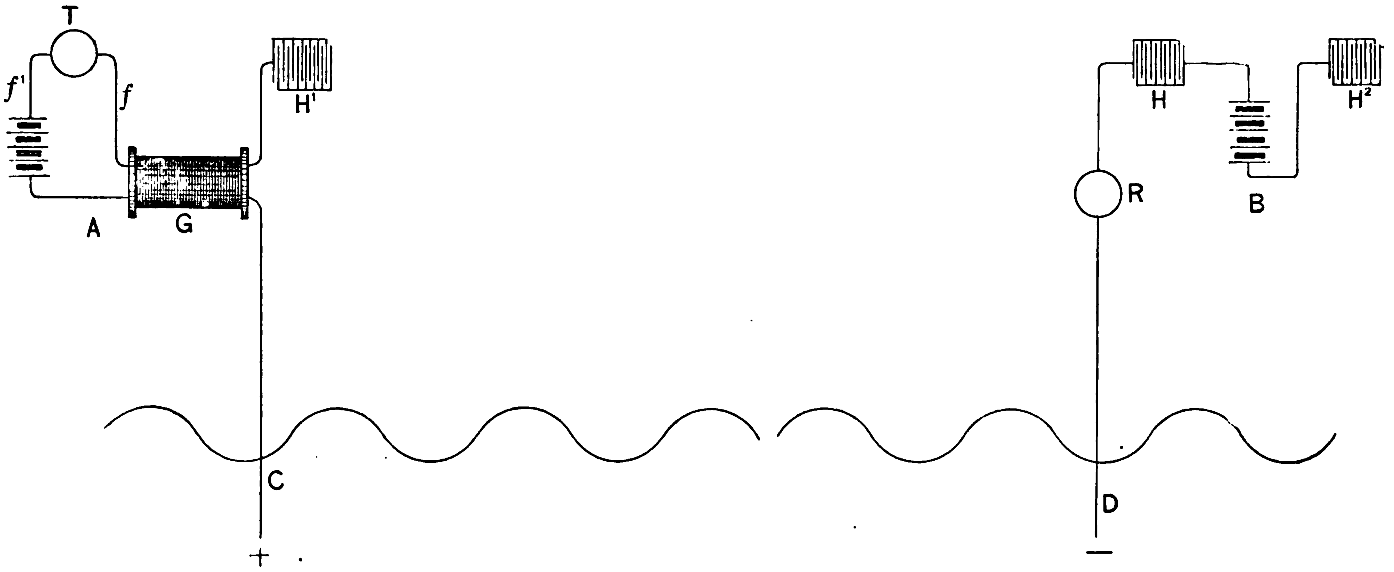
ELECTRIC COMMUNICATION WITHOUT WIRES.

The mode of electric communication, for which a patent issued to Prof. A. E. Dolbear, Oct. 5, has much scientific interest.

Below we reproduce the drawing of the patent. The principle sought to be utilized is obvious from an inspection of the drawing.

The following explanation of the drawing is from the specifications of the patent.

"In the diagram, *A* represents one place (say Tuft's college), and *B* a distant place (say my residence).



"*C* is a wire leading into the ground at *A*, and *D* a wire leading into the ground at *B*.

"*G* is a secondary coil, one convolution of which is cut, the ends thus formed being connected with the poles of the battery *f*, which has a number of cells sufficient to establish in the wire *C*, which is connected with one terminal of the secondary coil *G*, an electromotive force of, say, 100 volts. *G* in this instance also represents an induction coil, *T* being a microphone transmitter, *f* its primary circuit, and *f* its battery—that is, the battery *f* not only furnishes the current for the primary circuit, but also charges or electrifies the secondary coil *G* and its terminals *C* and *H'*.

"Now, if words be spoken in proximity to transmitter *T*, the vibration of its diaphragm will disturb the electric condition of the coil *G*, and thereby vary the potential of the ground at *A*, and the variations of the potential at *A* will cause corresponding variations of the potential of the ground at *B*, and the receiver *R* at *B* will reproduce the words spoken in proximity to transmitter *T*, as if the wires *C D* were in contact or connected by a third wire.

"There are various well-known ways of electrifying the wire *C* to a positive potential far in excess of 100 volts, and the wire *D* to a negative potential far in excess of 100 volts.

"In the diagram, *H H' H²* represent condensers, the condenser *H'* being properly charged to give the desired effect. The condensers *H* and *H²* are not essential, but are of some benefit; nor is the condenser *H'* essential when the secondary *G* is otherwise charged. I prefer to charge all these condensers, as it is of prime importance to keep the grounds of wires *C* and *D* oppositely electrified, and while, as is obvious, this may be done by either the batteries or the condensers, I prefer to use both."

The principle is set forth in the claim of the patent as follows: "The art, above described, of communicating by electricity, consisting in first establishing a positive potential at one ground and a negative at another; secondly, varying the potential at one ground by means of transmitting apparatus, whereby the potential of the other ground is varied; and, lastly, operating receiving apparatus by the potential so varied, all substantially as described." Prof. Dolbear states that communication by this method is practical to a distance of half a mile at least. Its possible range has not yet been determined.

Prof. Dolbear described the method of electric communication under notice, at the Montreal meeting of the American Association for the Advancement of Science in 1883.

We are indebted to him for some notes on the subject, not specially prepared for publication, but of much interest, and from which we are pleased to print the following:

"As to the experimental work. My first results were obtained with a large magneto-electric machine with one terminal grounded through a Morse key, the other terminal out in free air and only a foot or two long; the receiver having one terminal grounded, the other held in the hand while the body was insulated, the distance between grounds being about 60 feet. Afterwards much louder and better effects were obtained by using an induction coil having an automatic break and with a Morse key in the primary circuit, one terminal of the secondary grounded, the other in free air, or in a condenser of considerable capacity, the latter having an air discharge of fine points at its opposite terminal. At times I have employed a gilt kite carrying a fine wire from the secondary coil, the discharges then are apparently nearly as strong as if there was an ordinary circuit.

The idea is to cause a series of electrical discharges into the earth at a given place without discharging into the earth the other terminal of the battery or induction coil. A feat which I have been told so many, many times was impossible but which can certainly be done. An induction coil isn't amenable to Ohm's law always! Suppose that at one place there be apparatus for discharging the *positive* pole of the induction coil into the ground, say 100 times per second, then the ground will be raised to a certain potential 100 times per second. At another point let a similar apparatus discharge the *negative* pole 100 times per second, then between these two places there will be a greater difference of potential than in other directions, and a series of earth currents, 100 per second will flow from the one to the other. Any sensitive electrical device, a galvanometer or telephone, will be disturbed at the latter station by these currents, and any intermittance of them, as can be brought about by a Morse key, in the first place,

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will be seen or heard in the second place. The stronger the discharge that can be thus produced, the stronger will the earth currents be of course, and an insulated tin roof, is an excellent terminal for such a purpose. I have generally used my static telephone receiver in my experiments, though the magneto will answer.

I am still at work upon this method of communication, to perfect it. I shall soon know better its limits on both land and water than I do now. It is adapted to telegraphing between vessels at sea.

Some very interesting results were obtained when the static receiver with one terminal was employed. A person standing upon the ground at a distance from the discharging point could hear nothing,—but very little standing upon ordinary stones, as granite blocks or steps—but standing on asphalt concrete, the sounds were loud enough to hear with the telephone at some distance from the ear. By grounding the one terminal of the induction coil to the gas or water pipes—leaving the other end free, telegraph signals can be heard in any part of a big building and its neighborhood without *any connection whatever* to the conductor, provided the person be well insulated.

PRACTICAL DEDUCTIONS FROM THE FRANKLIN INSTITUTE TESTS OF DYNAMOS.

BY CARL HERING.

The tests of dynamo-electric machines, made in 1885 under the auspices of the Franklin Institute, are undoubtedly the most reliable and complete of all the impartial tests which have ever been made and published, and they therefore afford the practical electrical engineer an excellent opportunity to deduce proportions, dimensions and constants, to assist him in designing dynamos, especially as the machines which were tested are among the best that are made, and represent the results of tedious and expensive experimenting on the part of the makers, while, at the same time, they embody the improvements suggested by long and continued use of the machines in practice.

Dynamos have frequently been built by "guessing" at the proportions, constructing them, and then trying them to "see what they will give." If they then turn out (by chance) to give the electromotive force and current desired, the designer generally gets the credit for having made very correct "calculations;" while if they give, for some unknown reason, quite different results, the manufacturer has to be consoled with the statement that "it is not possible to calculate the parts of a dynamo."

If a machine is at hand which can be thoroughly tested and measured in all its parts, it is not difficult for a technical engineer, who is well informed concerning the principles and practice of dynamo building, to calculate the parts of another machine of the same type which will give a certain desired electromotive force and current slightly different from that of the first machine. But when the designer has no access to such a model machine, or if the current and potential desired differ greatly from those of the model, it is difficult, if not quite impossible, to calculate with any degree of certainty the parts of a dynamo from the principles and laws of induction and resistance, without some practical constants and proportions, which can be obtained only from existing machines.

As an aid and guide in such calculations, a set of practical constants and proportions have been calculated by the writer from the valuable tests of the Franklin Institute. These constants will not only materially diminish the amount of "guessing" in designing machines, but it is believed they are sufficiently complete to enable a technical engineer to calculate all the electrical proportions of a well-designed cylindrical armature which is to give a certain required electromotive force and current. It is to be regretted that the data given in the Franklin Institute Report are not sufficient to enable a similar complete set of constants to be deduced for the field. A few of these may, however, be calculated, and they will materially aid in determining certain parts of the field. The calculations of armatures being based on induction and conductivity, the constants from one armature may be used in calculating others; but in the field this is not the case, as the relation between the exciting current and the magnetism produced depends very largely on the size, shape and proportions, of the coils and the iron parts, including the cores, the so-called neutral parts, pole pieces, etc., as well as on the quality of the iron. As these are so very different in different machines, the constants obtained from one would be of little use in determining the size of other fields, except, perhaps, the constants given below for the intensity and amount of the magnetism of the field. A careful and systematic builder of dynamos will in most cases run the armature, when completed, with its own field magnet frame with temporary, removable coils of known number of turns, on the magnets, in order to find, by regulating the current in these temporary field coils, how many ampere-turns are required in the field to induce the desired electromotive force and current in the armature. From this number of ampere-turns any competent dynamo builder can readily calculate the proper windings of the magnets with all due accuracy.

Numerous theories of dynamo-electric machines have been advanced, but most of them are of greater interest to the mathematician and the physicist than to the practical dynamo builder. More attention seems to have been given to integrals, complicated abstruse fractions and formulæ for determining the presumably correct values for extreme impossible cases, than to simple, practical formulæ, by means of which tangible results may be obtained for the ordinary forms of machines. In some cases, formulæ based on physical theories have been suggested, which might have been of practical use if accompanied by the absolute and reliable values of certain constants usually represented by Greek letters, which enter as direct factors in the formulæ; but the values of these constants have either been omitted, or else have been given within such wide ranges that they cannot be used to any advantage in practice. They are sometimes of such a nature that they differ for each machine, thus necessitating the construction and testing of the machine before the values of the constants for calculating this particular machine may be determined; which is, to say the least, a very awkward way of applying a formula.

The writer has, therefore, set aside all abstruse theories of the dynamo, which have yet to stand the severe test of varied practical application, and has endeavored to deduce from the results given in the Franklin Institute Report some constants, or values, which are in such a form that they may be directly applied to the calculations of the armature and some parts of the field. The deductions of these constants are based only on the well-known laws of induction, and of mechanics, and as they are calculated from actual cases, they show what *is* done in practice, as distinguished from what *might be* done according to some theory, provided the theory is correct.

The results tabulated on the following page not only give the values which can be used in designing machines, but an attempt has also been made to determine the efficiency of separate parts; thus indicating under what circumstances the most advantageous proportions may be arrived at. Some proportions used in calculating the numbers given in the table were not contained in the report, and, therefore, had to be estimated, except where they were furnished to the writer by the kindness of the manufacturers. But the errors which may have been introduced by a slightly inaccurate estimate, are so small that they do not materially affect the results. Certain slight errors, or modifications, in some of the figures, or proportions, were not taken into account, as they cannot be determined; but they are of such a nature as to affect equally, or approximately so, all machines not

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differing too widely from the style of those tested. Among these is the self-induction of the armature; in well-built machines, like those tested in which the field is intense, the speed not too high, the number of commutator bars or coils large, and the number of windings per coil very small, the self-induction will be very small, and, therefore, the difference between the self-induction in these different armatures may be neglected.

In the table given below, the deduced constants have been accompanied by many of the proportions from which they were derived, as copied from the report, in order to show some of the principal proportions of the machines, and to give the conditions under which the constants have the values given. Numerous other values in the report might have been repeated here, but as it is presumed that any one can obtain the original report, they are omitted. The values chosen for the deductions were taken from that one of the full load tests in which the current and potential were nearest to the values given by the makers as the best working load.

assumed that the length of the armature core was the same as that of the pole pieces; in the Weston machines, this was the case.

As the electromotive force induced in an armature is dependent upon the amount of magnetism passed through per second, the first questions in designing armatures are: How great may the velocity of the moving wire be? What must its length be? What must the intensity of the field be? etc.

The first of these, the velocity of the moving wire—commonly called the "conductor or inductor velocity"—depends on the distance of the active wire from the centre of the shaft, and on the number of revolutions of the armature. It may be calculated from the speed and the mean of the external diameter and the diameter of the core. In the accompanying table, the horizontal column *a* contains the external diameters, *b* the internal, and *c* the mean. From this mean value the circumference in feet was calculated, which, when multiplied by the speeds *d*, and reduced to seconds, gives the inductor velocities in feet per second,

	Reference letter.	Edison No. 4.	Edison No. 5 or T.	Edison No. 10 or S.	Edison No. 20 or H.	Weston 6 M.	Weston 6 W I.	Weston 7 M.
External diameter of armature in inches	*a*	7.063	7.875	10.625	10.625	8.031	8.250	9.875
Internal diameter or diameter of the core	*b*	6.250	7.063	9.688	9.688	7.387	7.410	8.595
Mean diameter in inches	*c*	6.657	7.469	10.156	10.156	7.709	7.830	8.985
Speed in revolutions per minute	*d*	1600.	1400.8	1208.6	1092.1	1114.9	1257.6	1043.5
Mean inductor velocity in feet per second	*e*	46.5	45.6	53.6	48.2	37.4	43.0	41.0
Number of coils or commutator bars	*f*	50	50	64	44	72	56	64
Number of turns per coil	*g*	2	2	1	1	2	2	2
Total number of turns on armature	*h*	100	100	64	44	144	112	128
Mean distance between pole-piece projections in inches	*i*	2.69	2.313	3.50	4.88	2.52	2.58	2.94
Active part of circumference of armature in per cent. (approx.)	*j*	76	80	80	71	80	80	80
Length of pole-piece or armat. core in inches	*k*	12.	13.	16.5	29.5	14	14	16.5
Total E. M. F. in volts	*l*	131.91	131.5	129.35	129.60	127.17	136.22	165.58
Mean induction in volts per foot	*m*	1.733	1.515	1.838	1.687	.948	1.304	1.175
Volts per foot for 1 foot per second	*n*	.0373	.0332	.0343	.0350	.0254	.0303	.0287
Mean intensity of field in lines of force per square inch	*o*	25,900.	23,000.	23,800.	24,260.	17,630.	21,000.	19,900.
Amount of magnetism in field in lines of force	*p*	2,660,000.	3,090,000.	5,250,000.	8,600,000.	2,420,000.	3,042,000.	3,860,000.
Energy in field in horse-power	*q*	.394	.401	.675	.862	.207	.402	.498
Useful lines of force per volt-ampere in field, (relative efficiency of field)	*r*	90.2	103.1	104.1	133.5	161.1	101.5	103.7
Length of wire in one coil in inches	*s*	92.	102.	68.	98.	154.	151.	160.
Total length of armature wire in feet (parallel wires considered as one)	*t*	383	425	363	359	924	705	853
Available active length in feet	*u*	152.0	173.4	140.8	153.6	268.8	209.0	281.6
Percentage of same, which is active	*v*	40	41	39	43	29	30	33
Diameter of naked armature wire in inches	*w*	.148	.180	.199	.199	.141	.190	.175
Number of wires in parallel	*x*	1	1	3	3	1	1	1
Total current in armature	*y*	84.42	103.31	205.50	392.42	72.84	100.60	128.16
Square mils of cross-section per ampere	*z*	407	492	606	475	428	562	374
Percentage of energy in armature	*A*	3.70	4.65	3.12	3.39	5.43	3.09	5.59
Total electrical energy in horse-power	*B*	14.93	18.23	35.67	68.25	12.43	18.39	28.47
Relative efficiency of armature as an inductor	*C*	11.33	8.44	7.90	10.17	4.32	4.62	6.94
Useful commercial efficiency of machine	*D*	88.38	89.76	89.70	91.90	87.38	90.21	89.92
Depth of winding in inches	*E*	.407	.406	.469	.469	.322	.420	390
Percentage of diameter taken up by windings	*F*	11.5	10.3	8.83	8.83	8.02	10.2	8.32
Distance between pole-piece projections divided by depth of windings and clearance	*G*	5.0	4.4	5.9	8.2	5.65	4.75	5.72
Ratio of length to diameter of armature core	*H*	1.9	1.8	1.7	3.0	1.9	1.9	1.9
Ratio of length to diameter of bearings	*I*	4.2	4.3	4.1	4.1	4.2 & 3.6	4.2 & 3.6	3.8 & 4.3
Volts per commutator bar	*J*	6.7	6.25	4.9	7.2	4.2	5.9	6.1

The following assumptions were made, as the accurate data for deducing the same were wanting. The speed in the Edison No. 4 machine was not given in the report; that given here is the speed at which the makers say the machine is to be run, and it is assumed that the speed must have been very nearly this in the test. The percentage of the whole circumference of the armature which is embraced by the pole pieces was, in the Weston machines, assumed to be about 80%, as this was the proportion in some arc light machines of the same makers, which we understand have the same type of frame. The distance between the pole piece projections was determined from this in the Weston machines. In the Edison machines the length of the pole pieces and the armature core, were deduced from the statement in the report giving the length of useful wire in a coil; it was assumed that by the term, "useful wire," was meant that which lies directly between the pole pieces and the armature core. In the Edison machines it was

in column *e*. From these values, it is seen that the Edison armatures have a higher velocity of the moving wire; also, that it is preferable to obtain the high inductor velocity by making the diameter as great as practical, rather than to increase the number of revolutions, as will be seen by comparing the small, high-speed armature of the Edison No. 4 with the large one of the Nos. 10 and 20.

To obtain a constant by means of which the length of wire may be calculated, the total electromotive force in volts which was generated, has been divided by the length of that part of the wire in which it is generated. This wire will be termed the "active wire" and, in these deductions, has been limited to that portion of the armature wire which lies directly between the pole pieces and the armature core. Strictly speaking this is not quite correct, as some induction does undoubtedly take place in some parts of the wire lying at the ends of the armature, and also in some of the longitudinal wires which are not

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directly between the armature core and the pole pieces; but the induction in both of these parts is presumably so small as compared to that in other parts, that it may be neglected, especially as the constants are to be applied to similar armatures, thus eliminating this error. The length of the active wires were calculated from the following proportions. Column *f* gives the number of coils or commutator bars; *g* the number of turns per coil, and *h* the resulting total number of turns on the armature. The proportion of these coils which are active, is calculated from the distance between the pole piece projections, column *i*, and the circumference determined from the diameters in column *a*; the ratio of this is given in column *j*, in percentage of the circumference of the armature which is active; this will also represent the percentage of the number of windings which are active. Column *k* gives the length of a pole piece in inches, which is the same as the length of the armature core. From these the total length of the active wire in feet can be calculated, remembering that every turn of wire on the armature represents *twice* the length of the pole piece; but as the two halves of the armature wires are in multiple arc only half of this induces the whole electromotive force. The total electromotive force in volts, given in column *l*, is then divided by this half length of active wire in feet, giving the induction in volts per foot in column *m*. As this induction is slightly different in different positions of the wire with reference to the pole pieces, these results give the mean value. They show that the induction is considerably higher in the Edison than in the Weston machines; also, that it is very nearly the same in all the Edison, and nearly the same in the three Weston machines.

These constants are dependent on the velocity of the inductor, for it is evident that if the latter were higher the induction would be increased. In order, therefore, to properly compare these constants, it is necessary to eliminate the velocity by dividing these figures by the velocities in column *e*, thus giving the volts per foot which would be induced (in the respective fields) at a uniform velocity of one foot per second. This is given in column *n*, and shows the number of volts induced per foot for an inductor velocity of one foot per second. These may be compared with each other as the velocities are the same. They show that at the same velocity the induction is better in the Edison than in the Weston machines; also that the values agree very closely for all the Edison, except for the No. 4 machine, which may possibly be attributed to the number assumed for the speed, which was not taken in the test. For the Weston 6 M it is lowest, which is no doubt due to a less intense field.

The next question which naturally arises is, what was the intensity of the field in these machines. This may be determined as follows: We know that a volt is 100,000,000. times the unit of electromotive force in the absolute system, and also that one absolute unit of electromotive force is generated when a wire cuts lines of force at the rate of one per second; therefore one volt is induced if a wire cuts 100,000,000. lines of force per second. As we know the number of volts in one foot (column *m*) in these machines, and also the number of feet moved through in one second (column *e*), we can readily calculate the intensity which the field must have had to induce that number of volts in one foot. To illustrate this, suppose the velocity was one foot per second, and that the induction was one volt per foot at this velocity, then it is evident that the surface moved over by one foot of wire in one second, that is, one square foot, must contain 100,000,000. lines of force; or, if the induction was two volts per foot, there must be 200,000,000. lines of force in this space, as this number must have been cut per second to generate two volts. Dividing this number by 144, will give the mean intensity of the field in number of lines of force per square inch. These figures are given in column *o*. They show that with one exception, all the Edison machines have very nearly the same intensity of field; also, that it is somewhat lower in the Weston, especially in the 6 M machine; but, as will be seen, it is more economically obtained in this one, which indicates that it was probably not over saturated.

These values might also have been obtained by multiplying those in column *n* by 100,000,000. and dividing by 144, which is equivalent to multiplying them by 694,444. This will be seen by considering the principles of the deductions.

The total useful amount of magnetism in the whole field is evidently the intensity per square inch multiplied by the size of the field in square inches. As the intensity has been calculated from the amount of induction, the amount of magnetism thus obtained does not include the leakage of the magnetism, that is, those lines of force which are not cut by the armature wire, it therefore represents the useful magnetism only. The same lines of force which enter the armature at one pole piece pass through it to the other pole piece, and therefore the total number of lines of force is the intensity multiplied by the curved area of one pole piece. These figures are given in column *p*, and are deduced from columns *o*, *a*, *j* and *k*. The magnetism increases with the number of volt-amperes which the machine generates.

This amount of magnetism is generated at the expense of a certain quantity of electrical energy in the field magnets. In order to get some approximate values for calculating roughly how much electrical energy will be required for generating, in practice, a certain amount of magnetism in similar fields, the figures in column *p*, may be divided by the amount of energy in volt-amperes, which was required in these cases to generate the respective fields. In the report the figures in column *q*, are given, which are the energy in horse-power consumed in the fields. Unfortunately the resistance of the field without the regulator box was measured only in one machine, so that the energy given here represents more than that used in the field magnets themselves, thus introducing an error in all the deductions made from these values. It is presumed, however, that at full load the resistance in the box was not large, so that the error will probably be small. Reducing this energy in the field to volt-amperes and dividing it into the amount of magnetism, gives the number of useful lines of force generated per volt-ampere in the field. These are given in column *r*. As they depend on so many different proportions of the parts of the field and magnet coils, and also in a measure on the armature, they might vary considerably for different types of field magnets, and can, therefore, be used only in making rough preliminary calculations. They agree tolerably well for these fields, except for the Weston 6 M, which is evidently better proportioned than the others. As these figures are the ratio of that which is produced to that which is required to produce it, they may be said to represent the *relative* efficiencies of the different fields, in which sense they represent no absolute efficiencies, but serve simply to compare the efficiencies with one another. In the Edison machines we believe wrought iron alone is used, while in the Weston both wrought and cast iron were formerly used together, and we presume were used in these machines also. Possibly the iron in the field of the Weston 6 M machine is not over saturated, which may be the reason of its high efficiency of field.

The wires of the armature being wound repeatedly around it, pass through the same field a number of times, thus utilizing the same field in one revolution for successive inductions in the same wire. This number of turns, as given in column *h*, multiplied by column *j*, may therefore be said to represent the economic use of the field; it does not follow, however, that the best armature is the one having the greatest number of turns on it, as it is quite the reverse, other more important considerations, such as

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self-induction, sparking, etc., require that the number of turns of wire be as small as practicable.

In deducing the number of volts per foot, only the active wire was taken into consideration. In designing armatures it is therefore necessary to know what the proportion is between the active and the total length of the wire, for if the active length is determined first from the number of volts to be generated and the induction per foot, we must find what the total length is in order to determine the resistance or cross-section of the wire. This proportion of active to total length will evidently depend on several dimensions of an armature, and will, therefore, vary somewhat in different machines. For these machines it was determined as follows: column *s* contains the mean length of wire in one turn (where several smaller wires are in parallel they were considered as one); this multiplied by the number of coils in column *f*, gives the total lengths in column *t*; these divided into the active length in column *u*, give the percentages in column *v*. From the latter it will be seen that the economy of the wire is considerably better in the Edison than in the Weston, and that it is best in the Edison No. 20, the proportion between the length and diameter of the armature being greatest in this one. Most of the proportions from which these percentages have been deduced were given by the makers.

The density of the current in the armature wire can be determined from the diameters of the wire in column *w*, the number of wires in parallel in a coil, in column *x*, and the total current in the armature in column *y*. Dividing the latter into the double area of cross-section of the wire in square mils, or the double sum of the cross-sections of the parallel wires, gives the number of square mils per ampere in column *z*. These numbers vary somewhat with the current and with several other proportions; they should, therefore, be used only as a general guide, or for making preliminary calculations. The best method for determining the cross-section, is to find the resistance from the amount of energy which is allowed to be lost in the armature, which together with the total length of the wire as determined from the induction per foot, etc., gives the required cross-section.

The percentage of energy in the armature as taken from the report, is given in column *A*. Those in which the loss is least, Weston 6WI and Edison No. 10, have the greatest area of cross-section of wire per ampere (column *z*), while the one in which the loss is greatest, Weston 7 M, has the least cross-section per ampere. This relation does not necessarily exist between them all, as the percentage of loss depends also on the induction per foot of wire, and therefore on the length of the wire.

The relative efficiencies of these armatures, as inductors, may be seen from the figures in column *C*. The efficiency as an inductor, apart from that as a converter of energy, is greater the larger the total amount of electrical energy induced (column *B*), and the less the amount of wire necessary to effect this induction; it may, therefore, be expressed by the quotient of the two. The figures in column *C* have, therefore, been calculated by dividing those in column *B* by the lengths in column *t* and by the double area of cross-section determined from columns *w* and *x*, the decimal point being changed to reduce them to a convenient form. By themselves these figures represent nothing, but by comparing them with one another they show which of the armatures are the best proportioned as inductors. They show that the Edison are considerably better proportioned than the Weston. The most efficient armature is, strange to say, the smallest one, Edison No. 4, which is no doubt due to its having the most intense field (column *o*), the highest speed (column *d*), and almost the smallest cross-section of wire per ampere (column *z*); this higher efficiency is, however, obtained at the expense of the efficiency of the field, as will be seen from column *r*; the useful commercial efficiency of the whole machine is, therefore, below the average, as seen from column *D*. Next to this armature, in point of efficiency as an inductor, is the largest one, Edison No. 20; its high efficiency is no doubt due to the great intensity of field (column *o*), the very small amount of wire on the armature (column *t*), the relatively high inductor velocity (column *e*), the large proportion of active wire (column *v*), and the comparatively small cross-section of the wire, per ampere (column *z*). The field of this machine has next to the highest efficiency as seen in column *r*, and therefore, as might be inferred, the machine has the best useful commercial efficiency of all of those tested, as seen in column *D*. It may be interesting to mention here that in this machine which has the best efficiency, the armature wires cut the field less frequently than in any other, as seen from the number of turns in column *h*.

Another proportion which may serve as a guide in designing armatures, is the relation between the outside diameter of the armature and the diameter of the core, or what amounts to the same thing, the percentage of the external diameter which is taken up by the wire on both sides. These figures are given in column *F*, and are obtained by dividing twice the depth of the windings given in column *E* by the external diameter in column *a*. This is greatest in the smallest armature, Edison No. 4, showing another disadvantage of small armatures; it is least and therefore best, in the Weston 6 M, which may partially account for the economic field shown in column *r*, as the latter depends on this non-magnetic space.

A few other proportions may be deduced from the data given. One of these is the proportion of the distance between the pole piece projections and the double distance, between the pole pieces and the armature core. This proportion should evidently be as great as practicable. The figures are given in column *G* and are obtained from columns *i* and *E*, allowing about $\frac{1}{16}$ of an inch for clearance on each side. It is greatest for the largest machine, Edison No. 20, which may partially account for its economic field in column *r*. The reciprocals of the figures in column *G* may be said to represent approximately the intensity of the leakage of magnetism, as compared to the intensity of the useful field at these places, as the lines of force have the choice of these two paths. But this will be only a rough approximation as a field is always more intense at points or sharp edges.

Another useful proportion is the relation between the length and diameter of the armature core, as deduced from columns *k* and *b*. It is given in column *H*, which shows by comparison with column *v* the advantage of a long armature. The Weston machines appear to be quite uniform in this respect, the length being almost twice the diameter.

Column *I* gives the relation between the length and diameter of the bearings.

Column *J* gives the electromotive force between two neighboring commutator bars. If this is great enough to maintain an arc across the insulation of the commutator bars (about 20 volts) there is danger of starting the well-known flash, encircling the whole commutator, if the brushes should be misplaced sufficiently far to start the arc. It will be seen to be far within the limit of 20 volts in all of these machines.

The Edison Nos. 10 and 20 machines, afford a good opportunity to compare two armatures of different lengths, but having all the other sizes and proportions alike, including the number of windings, size of wire, depth of winding, etc., only that in the one three wires are connected in parallel, and in the other, two; and that in the No. 20 the distance between the pole piece projections is greater, making a difference of about 10 per cent. in the number of active wires in favor of the smaller one. The chief gain of the long armature is seen in column *v*, in which it has the highest percentage, which partially accounts for the efficiency in column *C*, and the consequent commercial efficiency in column *D*.

The subject of self-induction of the armature was purposely omitted here, partly because insufficient data are given in the report to make any practical deductions

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regarding it, but principally because it is presumed that the self-induction in such armatures as these, with very few turns, is so small that it may be neglected in such rough values as have been deduced here. It is to be regretted that the resistance of the field coils without the regulator box was not measured in each case in order that the effect of the self-induction of the field coils in increasing the apparent resistance could be calculated, and its relation to the number of pulsations or commutator segments determined. In only one case was the field resistance measured alone, and from this a calculation shows an increase of resistance of less than one-tenth of one per cent., and, therefore, probably less than the allowable error in measurement.

The fact that the Edison Nos. 5 and 20 machines gave way in the armature insulation, will not lessen the value of these deductions to the designer of dynamos, as this was presumably a defect in the details of construction and not in the proportion of parts.

The test of the 20-light machines were marked unofficial in the report because the preliminary run of ten hours was not on full load ; but they are no doubt sufficiently accurate for the deductions of the approximate values in the table.

The deductions made here are not for the purpose of comparing the commercial value of these machines, as it has been shown in the tests that they are practically equal electrically. The most important consideration in this respect would be the cost of the machines and the cost of maintenance and attendance, which cannot be considered here.

For the benefit of any one not familiar with these machines, it may be added that they are all simple shunt machines, with cylinder armatures.

In conclusion, it may be said that the values deduced in the table may not be free from small errors, as great accuracy was not possible in all cases, owing to the want of some few detail dimensions ; moreover, great accuracy has no particular value in such general deductions as these.

ELECTRIC LIGHTING AND AERIAL WIRES.[1]

BY C. C. HASKINS,

City Electric Inspector, Chicago.

There are certain terms used in electrical work which, for the better understanding of what is to follow, should be explained. Electricity is a force, not a substance. In this respect it is like heat, light or magnetism, and may be converted into either, as any one of these is convertible into any other. Certain metals conduct heat more readily than others. Those metals or substances which conduct or carry electricity more readily than others, are said to be better conductors. Those which are the best conductors have the least resistance, and, *vice versa*, those which the most perfectly obstruct the current are those which have the highest resistance. When we find a material or substance which is a very positively bad conductor, we call it an insulator. Dry air, dry wood, glass, porcelain, resinous gums, etc., these are all insulators. The metals, copper and silver first, are good conductors, while iron, having nearly seven times the resistance of either of these, would require to be seven times the size of a copper wire to offer the same carrying capacity to a current. If we overload either wire, that is, send more current through it than its capacity or size warrants, the flow is obstructed, and a portion of the current is converted into heat. Heat, then, is a result of resistance in a conductor, and it is to resistance—to this conversion of electricity into heat and light by resistance—to the work of overcoming an obstruction, that we are indebted for the electric lights of to-day. There are two general divisions of electric lights, known to the trade and to the public as well, as arc and incandescent. The first of these is named from its being the result of an electric arc, a flame of electricity.

This arc is caused by an obstruction which a space of dry air offers to the passage of a current. Its carrying capacity

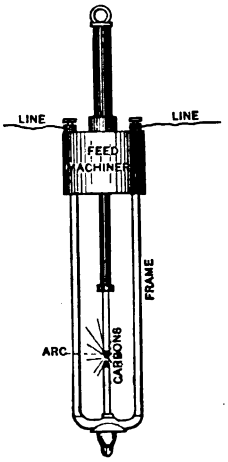
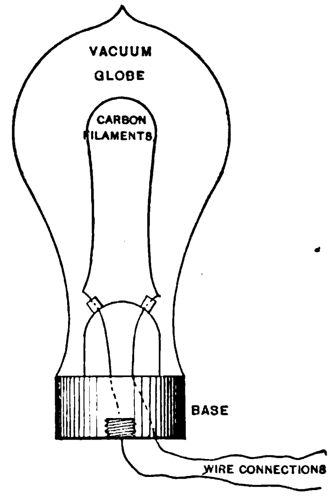


Fig. 1

is so inferior that the resistance transforms the current into light and heat. Two carbons, one on either side the arc, are slowly consumed. The incandescent light which, as its name indicates, is not a conflagration, but a white glowing heat, is the result, as in the former case, of resistance. The little wire-like loop is carbon. The space which the globe incloses is nearly enough so to be called a vacuum ; the air is virtually exhausted, and there being no air—no oxygen—there can be no combustion.

Fig. 2



Let us first examine an arc light circuit. The means of producing the current is virtually the same for both this and the incandescent system—the dynamo. This dynamo, or generator, sends a current out to line ; it comes to an obstruction at a lamp ; it jumps the obstruction, passes on to the next, and so successively at each lamp, and arrives home much the worse for wear. The dynamo is, however, constantly supplying a current, and a waste—or conversion rather, for nothing in nature is ever wasted—is constantly made good.

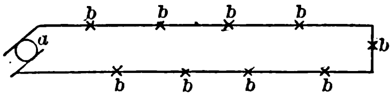


Fig. 3

Now, understand, this is the condition and performance of the current when the line is in proper order and form ; that is, when the wire is perfectly insulated, separated by

1. Address delivered at the seventeenth anniversary of the Fire Underwriters' Association of the Northwest, held in Chicago, Sept. 8th and 9th, 1886.

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some of those poor conductors—air, glass, porcelain, etc.—from contact with anything which leads to the ground, or some other line. The wire must be complete—a metallic path from the generator out through all the lamps and back to the generator. It must be of sufficient size to carry the current used without sensibly heating through the resistance it offers to the current; that is, it must be large enough. If it gets hot it is too small. Every portion of the line must be of sufficient capacity. Where the wire enters the lamp, where the ends of wire have been put together, at a joint, there must be full carrying capacity to prevent heating. Now, a line in which these conditions are fulfilled perfectly, that is, a line which is : *first*, thoroughly insulated from the earth and from possible contacts through which the current may escape, and get back to the generator by some cross-cut or short road ; and *second*, which has a wire of capacity sufficient to carry the necessary current without heating ; such an electric light plant is thoroughly and perfectly safe while it remains in that condition.

To enumerate the multitude of faults which may occur in a line to render it dangerous, would require much more time than the association would accord the subject. The two wires which run from the dynamo are often quite near each other for some distance, before they separate to go to line. These should not be less than ten or twelve inches apart. The nearer together they are, of course the greater the possibility of either getting them crossed, or of getting them connected by some conductor. I have known a fireman to hang his wet shirt on two wires to dry—a trick which cost him a new shirt. The resistance of a wet cloth will develop heat as well as any other resistance. The wire in this case was insulated, but fire-proof insulation is not water-proof, and water-proof insulation is not fire-proof, except where the insulation is made so by covering with metal. Gas men, plumbers, carpenters and engineers, while not wilfully mischievous, often do great harm after a plant is established, by running pipes, rods, or other fixtures for pumps, soda fountains, gas, sewerage, water or steam in close proximity to wires. They don't know any better, and they cannot be blamed, but must be watched. A short time since I found one of these large wires within about a half inch of a gas pipe. Normally it was safe. The space between the wire and the pipe was an excellent place in which to put an iron chisel, screw-driver or hammer. This would be quite natural. A wet towel would accomplish much the same result, create a ground connection, or what we technically call a ground.

Wires have sometimes been fastened to the plastered wall by iron staples. These may or may not be safe, temporarily, but it is not rare for the lathing in recent structures to be of wire, connected indirectly or directly to the ground. Wires running through damp places, as cellars, basements, etc., unless carefully guarded, are liable to form contact through dampness with water and gas pipes, either of which goes to ground.

Outside wires are full of expedients for getting a plant into trouble. Where they cross buildings, if there are other wires, either electrical or guy or stay wires, contact with these may mean a heavy loss in a block half a mile away. If the wire is a telegraph, telephone, police, or fire wire, its capacity for carrying is not equal to that of the electric light wire. If the current is deflected from its proper wire to the central office of the company whose wire is thus crossed, circumstances alone will decide what damage is to be paid for.

Some three years ago a small loss occurred which may serve to illustrate this phase of danger : A temporary line was run from a plant in the same block to furnish light for an evening entertainment. The wire was not insulated properly, and during the existence of this additional circuit a rain storm wetted the surface where the electric light wire rested, and formed a road for the current to a telephone wire. The telephone wire bore the indignity well enough until it reached the fine wire cable in the exchange. There it would withstand the insult no longer, and it burst into fire. The wire was too small to carry the current thrust upon it, and diminished size, as we have seen, means increased resistance, and resistance means heat. Ordinary water, then, may be made an element for producing fire. Why ? Because it is a conductor of electricity, while wood, wool, silk, etc., are insulators when dry. Hence a wet wall, a damp board, even a dish-cloth, might, under favorable circumstances, cause a severe loss to an insurance company. So, too, a wire on the face of a building is liable to come in contact with metal cornices, columns, posts, frames, etc., and I consider the long loops of wire which lead from a building to an outside lamp which is suspended from a rope particularly dangerous. These hangings are hazardous to both persons and property. The pulley rope, by which the lamp is lowered and raised, being no essential part of the light proper, is never looked after, as a rule, until the weather has perhaps materially reduced its strength, or it has given way. Some half a dozen or so of these have fallen in Chicago through the neglect of this rope.

A still worse feature in this form of hanging is the almost constant certainty of grounds where these wires flap against rods, frames, etc., and are wrapped up in the awning, which latter may be wet at any time. A remedy for this form of danger is found in a hanger manufactured by the Electrical Supply Company, which costs a mere trifle more than a plain rod. There is no reason why the underwriters should not demand the use of some such expedient as an additional element of safety.

I have frequently referred to the danger arising from a ground connection. Franklin, among other quaint things, said : "Take care of the pennies and the pounds will take care of themselves." One penny is but a small amount for either good or evil. One ground on a line can do no possible harm ; and if we can keep the first ground at a proper distance the second will take care of itself. I have said that the current which any conductor will carry is proportioned to its capacity—the same as a water pipe ; and if we have two conductors, one twice as large as the other, leading from the same source, one of these will carry twice as much as the other. The ratio is in proportion to the capacity.

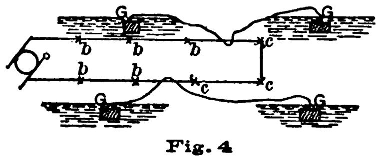

Fig. 4

The current from the dynamo starts out on the line, and finds on its way a ground connection, say one-quarter of the way round. Three-quarters of the way round there is a similar ground. In this case a certain amount of current is cut off and goes to earth at each of these points, and the lamps in the farther half of the circuit are deprived of just so much current energy. The amount which will escape at these two points will be in proportion to the carrying capacity. If the grounds are good, they will cut out the lamps beyond them entirely. If the line is a better conductor than the ground, more current will transverse the wire than waste at the leaks. If one of these happened to be a telephone wire, a fire might be the result, and if one of them happened to be an underwriter, a funeral might be in order. But if either of these occurred and there was no other ground on the line, there would be no work for either the adjuster or the coroner.

The incandescent circuit—and by circuit we mean the wires which carry a current—must also be kept free from contact with the earth. The current used by the incandescent systems is less fierce than that used by the arc systems. We say of steam at ninety pounds that its pressure is greater than at eighty pounds. So of electricity, we have

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what may be understood as high and low pressure. The highest pressure we can create is shown in that which is generated by a frictional machine, and comes nearest to that of nature. The lowest pressure is that which we accumulate by means of batteries, such as are used in telegraphy. We have quantity also, which is but another name for a result of low resistance. Now, the incandescent system uses a current of such low pressure that it is far more easily controlled and kept in the straight and narrow path than its wicked partner, the arc current. The wires, too, are differently placed. From either side of the dynamo the two wires are carried parallel out to the end of the circuit, say the upper floor of the building. They are not joined together at that point, but left open.

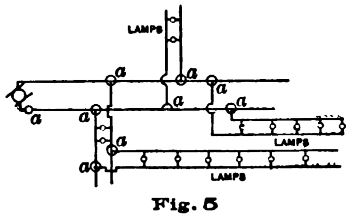


Fig. 5

Now, from a given point on these, say the first floor, a wire is carried at right angles from each of the mains down the halls on that floor. Opposite each room we attach a wire to each of these secondary wires, and run them parallel to the end of the room.

In all this wiring we have made no connection between the ends of the wires ; all these ends are open. Anywhere we like, governed by certain rules depending upon this matter of resistance again, we can put our lamps in, like rounds of a ladder, the branches leading into the room may be connected together by a dozen lamps, and the current has no way to get from one wire to the other, except to go over these little bridges—these lamps. There are modifications of this method, but they do not affect the question from our standpoint. You will naturally ask what safeguard there is in a system so placed. I answer this : At every point where there is a branch wire—at the junction —is placed a safety-strip, which protects the wire from that point to the last branch from the dynamo.

The action of the safety-strip is this : Being placed in the direct path of the current, it carries all which crosses that part of the circuit. Its carrying capacity is less than that of the wire, for it is made of a metal of higher resistance, and it melts at a lower temperature. If a screwdriver, or a nail, or any conductor, is made to connect the two wires leading to the two sides of the generator, the resistance is reduced at that point. More current crosses at that point than is useful ; the soft metal melts and cuts the line in two. A leak from a water pipe may form such a contact, and, before the building would be endangered, the increased flow of current would open the line, put out the lights on that branch, and cut off the dangerous current.

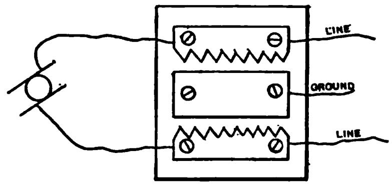
The soft, or safety-strip is graduated for the current it is intended to carry. Usually these are numbered for the number of lights they are designed to protect. The incandescent plant should not be allowed to run without safety-strips under any circumstances. It is the custom of some companies to put the safety-strip in the socket of the lamp. This is on the principle of fun for the boys, but death to the frogs. The lamp may be saved in case of excess of current, but the building may burn.

It is all well enough to place a safety-strip in the socket of the lamp, but the strip at the junction should not be omitted on any account. Care should be taken to see that the wires do not run in such a manner or through such places as to allow of accumulation of dirt, lint, inflammable dust, etc. I once found, in part of an incandescent circuit, a large accumulation of material just such as a rat would select for a nest, in contact with the wires ; and in an arc light circuit, where the two wires had dropped behind a store sign, I found a colony of sparrows. Were I asked, point blank, what faults shall we look for in a plant, I should hardly know what to answer, there are so many wrong ways of doing. These are so different, hardly occurring twice consecutively, that it is a matter of almost utter impossibility to answer such a question directly.

Two questions have been asked relative to the proper placing of a dynamo, which I will answer here. Outside the question of insulation, a dynamo may be looked upon as we would look upon any other rapidly revolving machinery. It should be as thoroughly insulated as any portion of the line, and must be considered as part of the line. It should be placed on a foundation selected and arranged so as not to endanger the building by vibration. The fire hazard is not increased by the dynamo, when this is properly protected by insulation. It has been sometimes suggested that an electric light system served to fill the air—saturate it, so to speak—with electricity, and thus endangered the building. As long as a line is insulated properly, so long the current will remain on the wire. With a ground elsewhere on the line, a second leak might occur in a damp —very damp—room, through the moist air to ground ; but with a well-insulated line this could not occur. With dry air such a saturation would be impossible. Magnetism is always present in a room where a dynamo is, but this force is harmless to persons and insured property. It is, however, ruinous to good watches, the steel parts of which absorb and retain magnetism.

Some other questions, asking specific answers, have been propounded, which, without repeating, I will endeavor to elucidate. Where a line is of the central plant variety—by which name we designate a plant running lights for rentals for sundry parties—the wire is often quite long, and consequently exposed to atmospheric electric changes, which might possibly overcharge the wire. It is hardly probable that any result would occur other than the destruction of the dynamo. For the protection of these machines it is well to put in what is termed the lightning arrester, which will carry off the excess of current in case of surcharging of the line from the atmosphere.

Fig. 6



There have been many forms of arresters made, but none are thoroughly complete and reliable. The commonest form is made of three brass plates, with connections on the two outside ones, to the generator in one direction, and to the line in the other. The middle plate is connected direct to ground. The saw teeth are, by an electrical law, more competent for discharging a current than a plain surface would be. The objections to this form are, that a heavy discharge may create an arc, which the normal current will afterward maintain, or the teeth may be welded to the ground plate by the discharge. These faults are easily remedied, however, by stopping the dynamo, and, as the arrester is in the room close to the dynamo, the trouble is manifested immediately, and readily cured. Mr. E. A. Sperry is the inventor of an arrester, which is claimed to act promptly and perfectly, without these objectionable features.

I have never heard of any injury to person or property from such causes, but the placing of such lightning-catchers effectually protects from possible discharges of lightning. The current generated by the dynamo will not leave the

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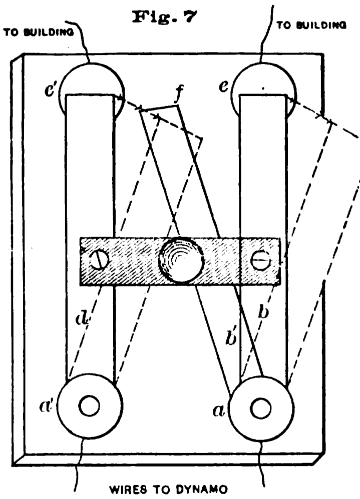
wire, except through a ground. The current, which is created in nature is on its travels, either from earth to cloud, from cloud to earth, or from one cloud to another; so that with all the other routes open to it, it is hardly reasonable to expect it to single out a copper wire on its way to the heavens or into the ground. As a matter of protection to the firemen, on such long circuits, it is not a bad idea to require placed at each building or block where the wires enter, a cut-off switch, which, being turned, completely cuts off the current from the locality or single structure; but even this, if wires are properly placed, is hardly necessary.

Fig. 7



The cut-off switch may be of any form which will accomplish the complete separation of the building to be protected from the line. It differs essentially from a cut-out switch. The latter merely puts out the lights, but does not separate the building from the generator. In the cut shown, the wires come from either side of the dynamo to the building posts, *a a'*; *bb* are brass, and virtually one piece. There is a handle of wood, or some other insulator, by which the switch is moved; *d* is another brass strip; *e e'* are two brass studs, to which the wires running into the building are connected. As the switch stands in its normal position the current enters at *a*, passes through *b*, *e*, thence through the building to *e'*, *d*, *a'*, and back to generator. Now, when we push the switch over we open the contacts at *e* and *e'*, but close the circuit at F, so that the current from the dynamo cannot get beyond that point.

To my mind there is but one sovereign panacea which can cure the ills of the electric light business. No plant should be permitted to run until a thorough inspection has been made by a competent electrician, with power to enforce his suggestions. And I believe it would be money in the treasuries of the fire insurance companies to be at the expense of such inspections, dividing this *pro rata* among the benefited companies, or on some modification of such a plan. I have not given the subject thought beyond this crude suggestion. In my opinion, no wire for electrical purposes should be allowed above ground. While these are permitted to swing in the air, from poles and housetops, contact with other wires is almost certain, and where these are telephone, telegraph, or other grounded lines, the result, if one such is crossed with an electric light wire, might be disastrous. With these in the ground the wind and weather can have no effect, and such a thing as a cross would be next to an impossibility.

In conclusion, it seems to me, if I may be allowed to express an opinion, that the insurance companies are quite the proper parties to urge both these points, and they certainly can, if it is deemed expedient, control the former. The experience in Chicago is certainly well worth attention and consideration.

THE DISTRIBUTION OF ARC AND INCANDESCENT LIGHTS ON THE SAME CIRCUIT.

BY HERMANN LEMP.

THE popular demand for the electric light in the past few years has been the cause of the establishment of central stations for electric lighting in most towns of any importance throughout the United States.

One of the first questions which suggests itself to the promoters of such an enterprise is, "What system is most suitable for our town? Incandescent or arc? The inability of either system to fulfill all requirements makes such a decision a difficult one. It is universally conceded that the field for arc lighting should be confined to out door illumination, and the lighting of large areas, where an even distribution of light is not essential. The proper field for incandescent lighting is in private dwellings, factories, and all places where a more complete sub-division and distribution of the light is desired.

Since the illumination of a town cannot be complete with one system, it very often happens that towns not large enough to support separate stations have to do without the electric light entirely.

Actual experience has shown that the introduction of one system in a place where the other existed already, led to the ruin of both through competition.

The capitalist, as well as the electrical engineer, naturally directs his attention towards such a combination of the two systems as may yield the advantages of each without additional complication.

Prof. Forbes has discussed the different distribution systems in his Cantor lectures, which have been reprinted in the ELECTRICIAN AND ELECTRICAL ENGINEER, and I will, therefore, but briefly mention them. One of the most common is the multiple arc system, as put in practice typically by Mr. Edison; on the same principle but with higher economy in regard to conductors, is the three or multiple wire system, used, also, by Mr. Edison.

The advantages of these systems are:—

1. Safety in regard to electric shocks.
2. Great independence of individual lamps.
3. Their close analogy to the well-known water or gas supply facilitates in their comprehension and manipulation by the inexperienced.

The disadvantages are:—

1. The area of supply from a station can hardly exceed a half mile square.
2. The price of the copper conductors enters as a very heavy percentage in the first cost of the installation.
3. Energy wasted in conductors can seldom be diminished to less than ten per cent.
4. With a given conductor the greater the number of lamps supplied from same, the greater percentage of energy wasted.
5. In order to maintain the difference of potential throughout the system constant, complicated apparatus and numerous indicators are required, for the operation and understanding of which well trained employés are necessary.
6. Frequently, especially where long distances are concerned, lamps requiring different E. M. F. have to be used in order to obtain uniformity in candle power.

This complicates the electrical and business management, necessitating great care in the renewal of lamps. The liability to overheating of conductors through short circuits and grounds is also a serious objection. There remains yet to be shown a practical method of combining the arc light with the parallel system of distribution to meet these constantly increasing cases in which such a combination is desired. It is well known that the arc lamp will not give satisfaction if an E. M. F. of more than 50 volts is employed. The light immediately loses its agreeable tinge of pure white, slightly yellow, and acquires a bluish color full of actinic rays, so hurtful to the eye.

Any parallel system of distributing incandescent lamps

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at so low a potential as 50 volts has long since proved uneconomical, and has been replaced by an E. M. F. of 100 volts. But this entails the placing of two arcs in series, the worst condition possible, since the maximum variation in the resistance of an arc then becomes 50 per. cent. of that loop of the circuit. There is one way which will give satisfaction, but which is not economical; that is, to replace one of the lamps by dead resistance, or by a group of 50 volt incandescent lamps. In neither case, however, is the combination a desirable one. There are several more systems of distribution to be considered. Of these, two, viz., those of Messrs. Goulard & Gibbs and the Brush Co. employ a primary series circuit, the former to energize their secondary generators, the latter to charge accumulators. The former has been so well described in the articles of Prof. Forbes, who had an opportunity to see its working, that any further explanation is rendered unnecessary. There is one point which I should like to touch upon: *i. e.*, the breakage of the line wire overhead or underground, which may happen with the same probability as in the common series system, would produce the same result, viz., extinction of the lights on the whole circuit.

In the Brush system secondary batteries are charged during the daytime in series from the regular arc circuit, and during the night are disconnected entirely from the same. The batteries are then allowed to discharge through their local circuit. This system though not very economical, nor entirely reliable, has at least the great advantage of securing safety to the consumer. Another system based on the reversibility of current in motive power, and *vice versa*, has, to my knowledge, never received any practical trial.

We come now to the methods in which incandescent lamps are actuated direct on arc lamps series circuits. Of these there are two; the first and more generally known is the multiple series system in which the main current is divided into so many parts as to give to every lamp the required amount of current.

The number of lamps to be run in a group depends, therefore, on two factors, viz., the total current used for arc lamps, and the individual current needed for each incandescent. It is erroneously stated that the number of incandescent lamps replacing an arc lamp is that number contained in a single group;—thus, if the Weston arc current (which is 18 amperes) and 100 volt lamp of 0.66 amperes are used, a group of 30 lamps would be obtained. But it is plain that not one but four arc lamps have been replaced.

To protect the lamps from too strong a current numerous safety devices have been constructed. In some we have a cut-out which replaces the broken lamp immediately by another, or equivalent resistance coil. This device may be introduced into the socket of every lamp, or all these devices may be assembled in a distribution box, as in that of Thomson-Rice. The Thomas cut-out, frequently used in the west, short-circuits the whole group as soon as one filament breaks. This arrangement though undeniably effectual, is, to say the least, crude.

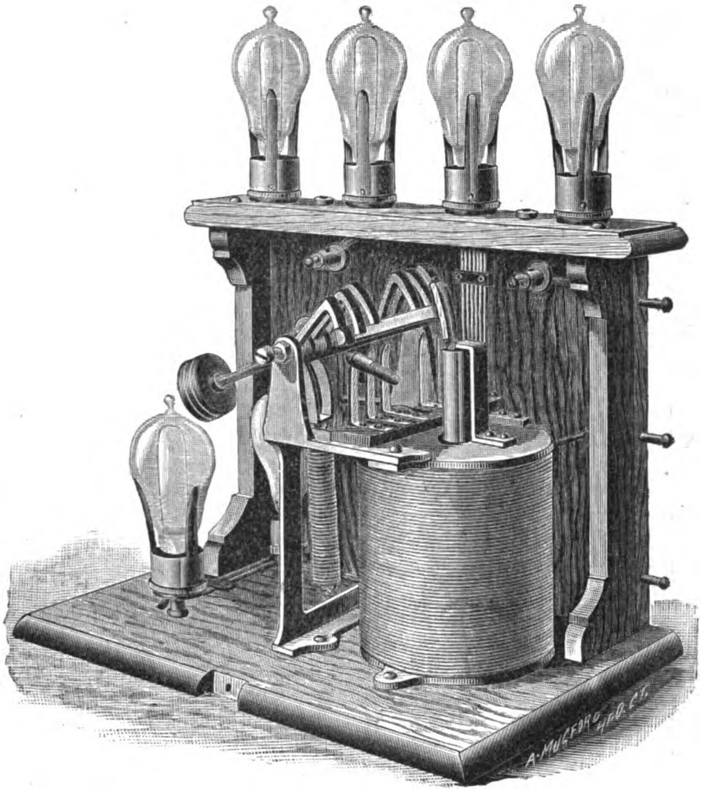
The above mentioned devices fulfill their protective duty, only in the event of the failure of a filament, but not if the total current should increase from one cause or another.

The distributor of Mr. M. J. Wightman, of the Schuyler company, has been designed to overcome these difficulties.

It consists of a solenoid of two coils wound in the same direction, one of high resistance connected as a shunt to terminals of lamps, the other a low resistance connected in series with the substituting resistance or lamps.

A movement of the core cuts in or out successively these resistances according to the rise or fall of potential. Its position depends upon the number of ampere turns surrounding it. The sum of ampere turns is composed of a constant derived from the shunt coil at normal potential, and a variable depending upon the current flowing through the main coil and substituting resistances. These resistances are preferably incandescent lamps both for simplicity and freedom from self-inductive spark on contacts.

This device is exceedingly simple, and has proved entirely reliable in practice. I understand that Mr. Brown, of Pittsburg, Pa., has also designed a distributor on similar principles, though of different construction. Although



these devices offer in a high measure safety and convenience the problem of incandescent and arc combination is but partially solved.

The system most in use at the present time is undoubtedly the series system as commonly applied in arc light distribution. The advantages and disadvantages of this system as compared with those of the multiple arc system, previously enumerated, are as follows:—

1. The area of district that can be economically lighted exceeds the largest of city limits.

2. In opposition to the multiple system the more lights that are used on a given circuit the smaller is the percentage of wasted horse-power.

3. The first cost of conductors is a very small percentage of the whole.

4. The regulating devices in the central station are very simple. There is but one condition to be fulfilled, that is, to keep the current constant. Automatic regulation can be easily obtained by well-known methods.

5. Overheating of conductors through short circuits or grounds cannot take place.

6. The charge of the installation can be given to any man of ordinary intelligence, without special scientific training.

7. Since the current throughout the whole circuit is constant, we require for all cases a given wire, and the matter of running new circuits is reduced to the simplest form possible, while in the parallel system of distribution the branch circuits require careful calculation, and, therefore, cannot be intrusted to inexperienced workmen.

8. The candle-power of lamps depending only upon current, can be kept constant, irrespective of the distance from the station, or the variation of the load due to the demand for light.

Among the disadvantages may be mentioned:

1. The danger from the use of high E. M. F., which

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danger may manifest itself in two different ways. A person may make contact with one of the conductors, directly or indirectly, and at the same time establish a ground connection through his body, and thereby endanger his life. It would also be fatal should a person insert his body in the main circuit by opening the same. These cases, however, can be and are guarded against by careful insulation of dynamos and lines.

In fact, if we compare the actual record of accidents resulting from high tension electric light currents with those from explosions or suffocation from illuminating gas, we shall find the number of the first comparatively small, in spite of the great increase of arc lighting and the carelessness with which such installations were formerly made.

2. Another disadvantage of the series distribution is the extinction of lights in the whole circuit, if the latter should get broken at any point. Such a contingency is best provided for by running an auxiliary line from a point situated midway on the external, or lighting circuit, to the central station switch-board, by which means the faulty half of the circuit can be immediately located, and the lights on the second portion saved from extinction. Nevertheless, actual experience has shown that the same circuit has been run for years without a break.

The running of incandescent lamps on an arc circuit has always been so tempting that numerous devices have been patented and tried, to fulfill this demand. Since July of the past year I have been experimenting in the laboratory of the Schuyler Electric Light Company, of Hartford, Conn., with the collaboration of Mr. Wightman, on the construction of an incandescent lamp, which might be inserted directly in the arc circuit of either ten, eight and a half, or six and a half ampere current.

The construction of this lamp, as well as the results obtained, led me to the belief that many of the readers of this journal would gladly receive some account of the same.

The above mentioned lectures of Prof. Forbes have shown me that another inventor, Dr. Bernstein, is also working on the same subject.

In such an incandescent lamp the two factors, volt and ampere, of which its electrical energy is composed, bear a very different relation to each other than is the case in the ordinary multiple 50 or 100 volt lamp. The filament, although of equal radiating surface per candle-power, is far shorter and of greater sectional area in proportion to the increased current strength and reduced E. M. F. required.

Before entering upon the details of this lamp, let me briefly recall some observations and theses made in connection with the common incandescent lamp.

Actual tests of the life of incandescent lamps have shown that, as a rule, 1,000 hours may easily be obtained with moderate candle-power. What are now the causes that lead to the destruction of the filament?

According to the researches of Prof. Crookes, there are four different states of aggregation, viz., solid, liquid, gaseous, ultra-gaseous or radiant. The cohesion of matter is diminished as it passes through the four states in the order enumerated. Therefore, any force that tends to the transformation of matter from a lower state of aggregation to a higher would lead to its disintegration. Such forces are:

1. The heat which is most commonly connected with the idea of transformation, as in melting and evaporation.

2. The absence of pressure, as illustrated in the evaporation of ether in vacuo, or the lowering of the boiling point of water.

The fourth state of aggregation—the one in which the individual molecules are the freest—can only exist in a perfect vacuum, such as is required for incandescent lamps, and results from either heat or electricity.

Another cause which helps forward the destruction of filaments is the repulsion of molecules charged with the same electricity of the same sign. The higher the potential the greater is the repulsion, and the shorter is the life of the filament.

The effect of this repulsion, as may be noticed in an ordinary incandescent lamp, is a diminution in size of one leg of the filament, and corresponding increase of the other, and also a blackening of the bulb.

Supposing we compare a 50 volt and a 100 volt lamp of equal candle-power. We shall find that the first is always more efficient. Is this result caused by the supposed leakage, finely dealt with by Mr. Preece, in his description of the experiment made on one of Mr. Edison's lamps provided with a special platinum discharge wire? Or is it not rather that the 100 volt lamp has to be run at a relatively low incandescence in order to prevent the more rapid disintegration due to the higher E. M. F.? It appears probable that the latter is the true cause, and that it is therefore advisable to reduce the difference of potential to a minimum in keeping the incandescence per square inch constant.

The filaments of an incandescent lamp appear to give the best results when composed of a hard crystalline carbon, as opposed to the soft black amorphous variety obtained by the carbonization of vegetable fibre in the usual manner. The crystalline carbon has a much greater density, and consequently lower specific resistance. Its refraction to heat is at the same time greater, and with a given rise of temperature it retains a relatively higher cohesion between its particles than is the case with the more loosely constituted carbon. It has been attempted by Mr. Cruto, of Turin, and Mr. Edison, in this country, to build up filaments entirely composed of this crystalline carbon. Mr. Cruto's method is to effect a deposit of hydro-carbon on an incandescent platinum wire, and subsequently to fuse out the latter by means of a discharge from a Holtz influence-machine; the remaining hollow carbon is then mounted in the usual manner. This lamp appeared at the Munich exhibition. The filament was efficient, but of too low resistance for practical distribution—30 volt for 20 candle-power. An attempt to increase the E. M. F. by a longer filament and thinner deposit failed on account of its mechanical fragility.

Mr. Edison obtained a patent for depositing carbon on silver or copper wire, and dissolving the latter afterwards in acid. A practical application of this has, however, never been made to my knowledge.

The high resistance lamps of the present time are, therefore, made of entirely untreated carbons, relatively short and thick, sufficiently strong to stand any common mechanical strain—as the lamps of Mr. Edison, and others.

Other filaments are made of a substance which, carbonized, has a very high specific resistance, and is brought down to a uniform standard through a light carbon deposit. Such are the filaments used by the Weston, Schuyler, and others. But even in these treated filaments the percentage of deposited carbon—taking the total as 100—is but very little; about eight per cent.

In the series incandescent lamp, which has formed the subject of my experiments, the results sought after by Messrs. Edison and Cruto have been in great measure attained by a different process.

The filament is practically composed of hard crystalline carbon of the usual horseshoe form, which, owing to its large sectional area and short length, is possessed of great mechanical strength, as also of the power to resist that disintegration brought in by electrical stress. It is evident that, for a given current strength, the candle-power of such a lamp is dependent only upon the length of filament. Although my professional engagements do not permit me to describe the manufacture of this filament in detail, I may remark that the process employed is of such a character as to allow the reproduction of similar filaments in commercial quantity.

These short and heavy filaments produce a more concentrated light than that of the common incandescent lamps, and appear to the best advantage when provided with a frosted bulb, which has the effect of diffusing the light

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and making it appear of a higher candle-power, even though in fact there is less.

A great advantage which the thick series filament possesses over the slender form is that it acts as a reservoir of heat, tending to equalize the irregularity of the light usually obtained from incandescent lamps on arc circuits. This advantage is not confined to its effect upon the eye, but has a direct and important bearing on the life of the filament.

I include herewith comparative table of filaments:

Type of filament.	Length of filament in inches.	Total cross-sect'n in square ten thousands.	Cross-sect'n of crystalline carbon alone in square ten thousands.	Percentage of crystalline carbon in total cross-section.	Ohms, cold.	Volts.	Amperes.	Candles.	Watts per Candle.	Remarks.
FF/20	7	4796	380	8	400	120	0.6	20	3.6	All filaments have the same candle-power, and nearly same radiating surface. In taking conductivity cold of a certain length, and cross-section of black amorphous carbon as 1, the conductivity of gray crystalline carbon will be 35 times greater.
F/20	6	5672	1256	22	120	60	1	20	3	
BS/20	2.5	31400	26984	86	2.8	9.2	6.5	20	2.5	
AS/20	2	56227	51811	92	1.6	7.	8.5	20	2.5	
DS/20	1.75	66148	61782	93	1.2	6	10	20	2.5	

An important factor for the life of an incandescent lamp is a perfect air-tight seal where the conductors pass into the bulb. Experiments have shown that platinum is the only metal the coefficient of expansion of which is the same as that of the glass. There is also a certain chemical composition, or quality, of glass required to obtain perfect fusion.

The difficulty of bringing the metal conductors through glass is greatly increased where a large current is used, since the necessary conductors convey a greater amount of heat to the point of fusion with the glass. These conductors are apt to vary in temperature more suddenly than the surrounding glass, which increases the liability of cracking. In fact, the difficulty needed a more careful experiment before it could be overcome, since it is just the difference of heat in the two bodies—platinum and glass—and not, as so often believed, the difference of expansion for the same heat, which results in cracking. It is necessary to use a conductor which has for a given cross-section the largest possible contact surface with the glass. For this reason the conductors are made of very thin rolled platinum sheet, and the glass caused to surround the same in equal proportion. See figure 8.

FIG.8.

With this seal the cracking has been entirely obviated, even with excessive current.

I come now to an important feature of the lamp, which is illustrated in figures 2, 6 and 7. This is the safety cut-out.

In the supplying of electric lights in series it is important to have included in every apparatus, be it an arc light or motor, or any other device, a safety cut-out, which in case of failure in the working of the mechanism will prevent either a dangerous arc or the opening of the circuit. These cut-outs, with a few exceptions, are placed in a high resistance circuit, as a shunt to the working device, which they short circuit, if the potentials should rise to an abnormal height. Here we encounter two obstacles which may be at least reduced if not entirely overcome.

1. The use of a fine wire which is so apt to burn out in case of lightning, or of a sudden break of the main line, between the terminals of said shunt.

2. The shunting off of useful current.

In the incandescent lamp which I am now describing, a different principle has been followed. Both platinum conductors are provided with copper bands, each wrapped around the opposite pole, but insulated from each other by a band of thin mica of greater breadth than the copper. On each conductor, therefore, both poles are brought into close proximity. The thickness of mica is about one-sixty-fourth inch, but the mica is so much broader than the copper as to make the total distance in vacuo around the edge of the mica equal to the distance between the two terminals. Therefore no leakage is possible, owing to close proximity of conductors, as stated by Mr. Preece in his above mentioned paper.

If, now, a filament should break, there will immediately appear an arc at the point of breakage. This arc will gradually extend until it reaches the mounts of the filament where the platinum tips become fused. The fused metal in progressing forms itself into a ball, which melting through the mica shield arcs over to the copper strip. The arc plays now between the two copper strips, the whole mass is fused into one solid ball, which in short circuiting the arc keeps the continuity of the circuit intact by means of an elegantly fused joint.

FIG.6.

FIG.7.

Figure 6, shows a cross-section of this cut-out arrangement, the black line representing the insulating mica.

Figure 7, shows the same after fusion has taken place.

In a system in which incandescent lamps of the above description are used, it is obvious that with every lamp an additional contact resistance is introduced into the circuit, and in order to prevent loss by heating in the socket of the lamp broad contact surfaces are required. It is also of vital importance that the insertion or withdrawal of a lamp should in no way interfere with the continuity of the line.

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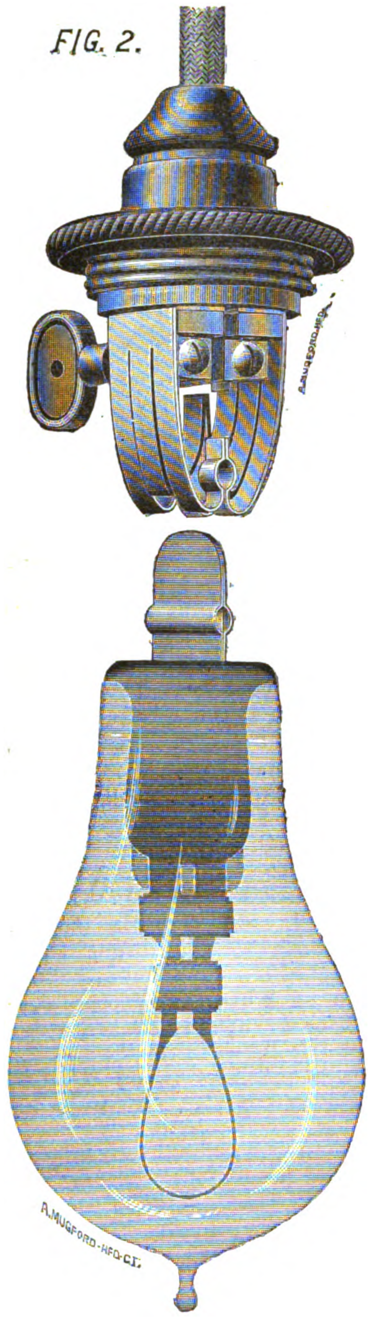
A condition strictly observed in the construction of these sockets, and plainly shown in the accompanying cuts.



In the base of each lamp are cemented two broad metal strips, separated by a thin strip of mica. These strips are connected with the terminals of the filament. In the socket itself are two slotted springs, mounted on an insulating base. These springs are included in the main circuit, and press normally against each other, thus affording a free passage to the current.

The peculiar bend of these springs is shown in figure 2.

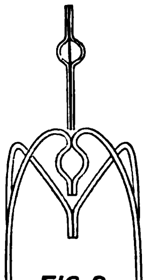


FIG. 3.

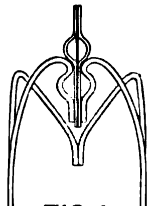


FIG. 4.

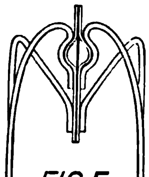


FIG. 5.

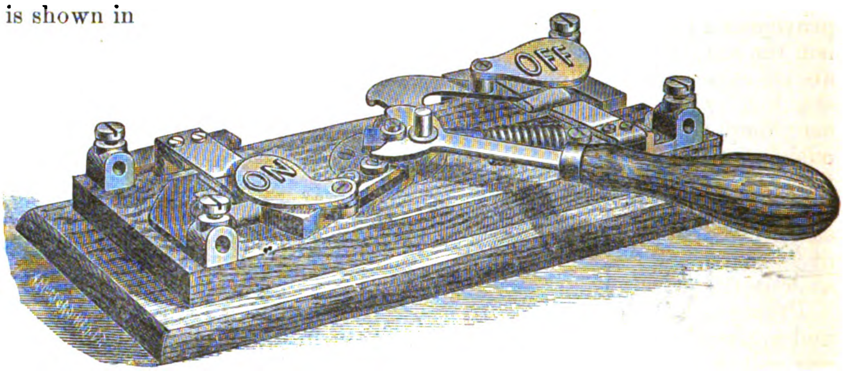
Figures 3, 4 and 5, show diagrammatically the different stages in the insertion of a lamp. In figure 3 all three parts of the springs are in connection with each other. In figure 4 the lamp is partly inserted, the upper parts making a thorough connection with the respective terminals of the lamp, whilst the lower still maintain the short circuit. A further movement separates also the latter, and allows the current to circulate through the filament. In order to lock the lamp in this position, the terminals are provided with an enlarged bend which fits into a corresponding recess in socket springs. All the metal parts are completely shielded by a fire proof and highly insulating cover, so that a personal contact with any of the conducting parts is rendered impossible.

It was stated at the beginning of this article that the greatest danger to the continuity of the circuit exists in those portions contained within stores or houses. A store circuit can at any moment be entirely disconnected from the main circuit by means of a common arc light cut-out, as illustrated in accompanying figure.

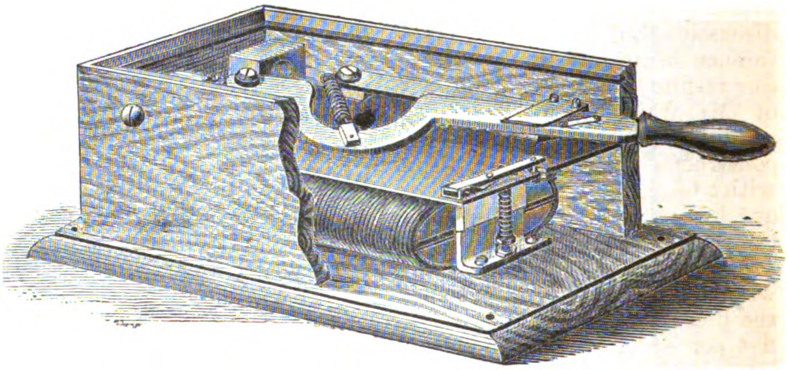
It is desirable to place this box upon a pole at a distance from the building in order to guard against destruction in case of fire. Within the building at the point where the wire enters, an automatic safe guard switch is placed, it serving the double purpose of safety cut-out and consumers main switch. It consists of a high resistance magnet which upon an excessive rise of potential attracts an armature, thereby releasing the main lever, and allowing the latter to close the circuit. The accompanying drawing shows its construction.

With an incandescent lamp of the above description, every fancy of the customer can be satisfied. He may have a 20 c. p. lamp over his desk, an arc lamp in middle of store, two 50 c. p. lamps for the show case, one in the back room, and they are all as thoroughly under control as in any parallel system.

The power absorbed is practically proportional to the



number and candle-power of lamps in use. A registering meter can be constructed which records the amount of energy used by consumers ; or the current may be delivered at so much per hour for a given number and kind of lamps.



One of the advantages of working these incandescent lamps in series with the arcs, is their tendency to steady the total circuit, which, on the other hand, when composed of arc lamps only, is generally fluctuating.

This combination of arc and incandescent lamps is already introduced into the stations and plants of the Schuyler Electric Light Co., by whom are controlled the patented apparatus which I have described, and to whom I am indebted for the cuts illustrating the same.

The rapidly increasing demand for these lamps seems to prove that this combination satisfies a long felt want in electric illumination.

This article was nearly completed before the appearance of Dr. Bernstein's paper, and the similarity of our ideas shows once more how many minds are working on the same subject. The present paper is published in its original form, without alterations, although, through strange coincidence some ideas have already been developed and perhaps in a better way by Dr. Bernstein.

In conclusion, I have taken the opportunity to add a few

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remarks upon the discussion, following Dr. Bernstein's paper.

Dr. Bernstein states that the heat developed in a filament through incandescence subjects the latter to varying expansions, which prove detrimental to its life. This expansion is only dependent upon heat, but I do not correctly see in this connection in what respect a high volt filament should be in more danger than a low one. The expansion is simply a certain percentage of the whole dimensions. He must be well aware of this fact, since he provided his filament with flexible spring connections. In my lamp, as in the common high resistance lamp, the shape of the filament itself allows for these variations. Dr. Bernstein seems to refer more particularly to the distribution of incandescent lamps alone, while my main object was a combination of the two, arc and incandescent. We have not arrived yet at that period when the incandescent lamp will entirely replace the arc.

I am rather inclined to think, that through recent improvements in carbon manufacture and regulating mechanism the arc lamp will always hold its field. As mentioned above, experience has shown me that the current is greatly steadied by the combination of the two. The incandescent lamps act as dead resistance, and the arc, like so many cushions (if properly constructed), tending to take up any fluctuations before a regulator or dynamo has time to accomplish the same result. It has proved financially necessary in business to be able to fulfill all possible demands of a consumer. This was one of the main objects I had in view in the working out of this system.

Proper care has to be taken in the installation of wires and apparatus to avoid too close proximity of water and gas piping, in fact of all metal objects which might come into contact with ground.

The difficulty of elegant suspension of Mr. Bernstein's lamps, is an objection to that particular shape, but this, is merely a matter of mechanical construction, and not of principle, and has been overcome in the lamp which I have described. The proper regulation of a dynamo for either constant E. M. F., or constant current, is a subject open to discussion, but I do not think that there is any great difference in its application to practice. Both systems show fair results if applied on a large scale. I am of the opinion of Mr. Evans, that the economy of two watts per candle-power must be obtained, and I think that filaments constructed as mentioned before will stand such a strain with a fair life. Experiments to that effect are carried on in our laboratory, the results of which I shall bring before the reader later.

Mr. Forbes' objection to loss of heat through conductors where they pass through glass is true to some extent. In the present lamp this loss has been brought down to about five per cent., but the objection is greatly over balanced through the economy in conductors.

The expense of the short circuiting arrangement, as above described, is but a small percentage of the lamp itself. There is no doubt that in the practical running of these lamps, advantages and disadvantages unlooked for will make themselves known, and it is reserved for the future to decide about the real value of such a system.

CORRESPONDENCE.

NEW YORK AND VICINITY.

More Electric Railway Talk.—Subway Progress.—Lighting up the Statue of Liberty.—Electric Light Tribulations in Orange.—An Electric Company Secures Exemption from a State Tax.—The Baltimore and Ohio Company Raises its Rates.

It would be somewhat curious, if after all the talk about electricity on the elevated railways, it should be practically adopted first for the surface roads traversing the same routes. This is one of the possibilities of the future, and is talked of more seriously perhaps since the adoption of a uniform five cent rate of fare has been adopted by the Manhattan company. Local transportation facilities must be increased if possible, for they are not yet equal to the demand, and perhaps never will be.

As was obvious to all who have had practical experience with new mechanical methods, the construction of the new electrical subway has been materially hastened during the past month by the growing experience of the workmen, and new machinery at the conduit factory. It is now going down at the rate of a block per day, and if the bulk of the wires on Sixth avenue can be coaxed into it this fall, considerable work may be accomplished next year.

It is rumored that the Western Union Telegraph Co. has secured a controlling interest in the conduit company, which, if proven to be a fact, will probably be a matter of more importance to electrical people than the supposed ownership and control by Maurice B. Flynn. The Averell company has kept up a vigorous fire on the conduit and its material through the columns of the *Sun*, and on the 16th instant quite a number of people interested in underground work were invited to that company's works in Brooklyn, to witness the construction of a sample of continuous duct conduit made of asphaltum concrete surrounding paper tubes.

The proposed method of lighting the Statue of Liberty is not entirely satisfactory to the daily *World*. The original plan was to place the lamps outside the torch, but it is said that on account of the objections raised by pilots against the Hell Gate light, it was decided to render them less conspicuous by placing them inside the structure, a portion of the shell being cut away and replaced by glass. The electrical plant for the work has been donated by the American Electric Manufacturing Co., after having secured the contract as the lowest bidder. The usual method adopted of advertising for proposals might have been reversed in this instance, and an effort made to see what company would pay the highest bonus for the privilege.

The bidding system has involved the city of Orange, N. J., in a little difficulty regarding its street lighting. The Fort Wayne Jenney Co. secured the contract and the lights were to be in operation October 1st. The formality of requiring a bond appears to have been dispensed with, and as time rolled on and no preparations were made for starting up, another seance was held, and the Thomson-Houston came to the front, and secured the contract, which, however, was not approved by the mayor, for the reason that on Dec. 1st., the date it was to go into effect, there would not be sufficient funds to the credit of the street lighting account to pay for a single month's service; so it is somewhat doubtful if the light of the future will appear in the streets of Orange just yet.

The Faure Electric Light and Force Co., of New Jersey, was one of a number of corporations which resisted the act of 1884 imposing a tax upon miscellaneous corporations. Under the law the attorney-general appealed to the court of chancery with a view to enforcing the assessment, and vice-chancellor Bird has just filed an opinion deciding against the state. His remarks in connection therewith are interesting.

"The facts," he says, "are, that although the company has been organized for more than three years, it has not transacted any business in the state nor out of it. It has only attempted to preserve its organization by the election of officers as provided by law. It has gone no further than this because it has been prohibited by injunction from other courts against the use of patents under which it expected to manufacture its wares. There is nothing in the act which seems to carry it to such a case. In my view the Legislature did not intend to assess the mere right or franchise independently of the business, to carry on which the franchise was granted. It is the exercise of the privilege thus granted that justifies the assessment or at least the interference of this court. The Legislature did not mean by one act to create a corporation, or allow a body corporate to be created, and then by another to give this court—a court of equity—the power to strangle it while still struggling for existence."

It is now evident that the recent advance in Western Union stock was caused by the adoption of a traffic agreement by which the Baltimore and Ohio company is to raise its rates to correspond with those of its great rival.

NEW YORK, October 19th, 1886.

PHILADELPHIA.

Electric Lighting at Lancaster.—The Philadelphia Bell Telephone Co. Directed by Councils to Lay its Wires Underground.—Other Underground Ordinances Considered.

Our suburban friends seem to be highly delighted with the electric light. At an entertainment given at the Opera House at Lancaster some evenings since, Mr. Shaw, the manager, promised to have the house lighted by electricity furnished by the Edison Electric Illuminating Co. Accordingly, on the evening in question, a number of the directors and stockholders of the company, and their friends, gathered at the electric light plant on North Arch alley, and the first business circuit was started by two little girls. Miss Rosa Sener, the seven-year-old daughter of J. Fred.

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Sener, the president of the company, turned on the steam that put the engine in motion, and Miss Miriam Sener, the ten-year-old daughter of W. Z. Sener, treasurer of the company, deftly switched on the dynamos. The illumination of the Opera House was all that could be desired. The big lights outside made the street as light as day, and inside the auditorium was brighter than it had ever been before.

Grace Lutheran Church was also brilliantly illuminated by 22 lights, and special services were held in honor of the occasion. The congregation was immense, extra seats being brought in to accommodate many who could not possibly be seated in the pews.

Lancaster has her little difficulties in reference to the right of way on poles, as well as the larger cities. The report of the fire committee called attention to the trouble arising from other wires than those of the fire alarm being on the poles of that system. Minutes of councils of several years ago were read, to show that the troubles were not of recent origin. The report stated that the committee could find no agreement between the city and the Bell Telephone Co. giving the latter the privilege of using the fire alarm poles. The minutes of June 3, 1882, show that an ordinance was presented, giving the telephone company the right to use the poles in return for the privilege of using *their* poles for the fire alarm wires, but there is no record of the ordinance having been adopted. The matter, on motion of Mr. Long, was therefore referred back to the fire committee, with full powers of acting in the matter as it deemed best, whether that involved removal of the telephone wires or not.

Electrically, it has been extremely quiet in Philadelphia for some weeks past. The only thing of any importance was the favorable report of the electrical committee of councils directing the Bell Telephone Co. to lay its wires underground through the central part of the city, the work to begin by the first of next November, and to be finished not later than January 1, 1889. An ordinance granting the American Telegraph and Telephone Co. the right to lay conduits and wires under a number of streets was referred to a sub-committee.

A favorable report was ordered of an ordinance granting the Postal Telegraph and Telephone Co. the right to lay certain conduits and cables, while a similar ordinance, giving the privilege to the Penn. Electric Light Co., was referred to the sub-committee.

PHILADELPHIA, October 16, 1886.

BOSTON.

New Hampshire Taxation of Telegraph and Telephone Companies.—Long Distance Telephony.—Telephone Stocks.—American Bell and Providence Telephone Companies.—Erie Telephone Co.—Electric and Gas Lighting in Boston Suburbs.—Wilson Police Alarm System in South Boston.

THE New Hampshire State board of equalization filed in the office of the state treasurer, on Sept. 29th, the following valuations of and assessments against the telegraph and telephone companies doing business in the state, for the present year:

Telegraph Companies.	Valuation.	Amount of tax.
Western Union	$155,000	$1,826.83
Mutual Union	2,000	23.57
Atlantic	7,000	82.50
Northern	5,000	58.93
Maine	10,000	117.86
Montreal	5,000	58.93
Chester & Derry	400	4.70
American	3,000	35.36
Direct United States Cable Co	20,000	235.72
Total	$207,400	$2,444.40

Telephone Companies.	Valuation.	Amount of tax.
New England Telephone and Telegraph Co.	$200,000	$2,357.20
Plymouth and Compton	5,000	58.93
Brattleboro and Hinsdale	500	5.89
Brattleboro and Chesterfield	700	8.25
Stratford and Colebrook	800	9.43
Colebrook, Stewartstown and Connecticut Lake	1,500	17.68
Colebrook, Stewartstown and Clarkville	100	1.18
Winnipesaukee Bell	8,000	94.29
Totals	$216,600	$2,552.85

Long-distance telephoning was satisfactorily tested between Hartford and New York, Sunday, the 26th ult., by Count Mitkiewicz, general manager, and Captain Moorhead, a director of the Turnbull Inter-Ocean Telephone Co. The United Lines Telegraph Co.'s wires were used, and manager Morgan of the United Lines office at Hartford, manager Knox of the Mackay-Bennett Cable Co., and other electricians were present.

Telephone stocks have been lively again, during this month, owing mainly to two reasons: First they participated in the general rise of the market; and second, they were sent up by the large orders to purchase from western cities. One broker alone received an order to buy 800 shares of American Bell stock.

There have been rumors, not well grounded, however, that the American Bell Telephone Co. had purchased the territory of the Providence Telephone Co. It is well known that the Providence company have not had a perpetual contract with the Bell company; if it should turn out that they had received a long contract, and that the A. B. T. Co. had received in consideration therefor a "proportion" of the capital stock, it would be in accordance with its settled policy.

The hearing in the Erie telephone suits begun at Lowell last spring, was to be resumed on the fifth of this month, but has been postponed until later.

The Erie Telephone Co. have declared the usual one-half per cent. dividend. The earnings for the quarter have been $16,000 in excess of the dividend, and the company's surplus is now upwards of $30,000.

The Electric Light Co., which has its lighting station at Malden, has connected by cable with Melrose, and the principal streets presented quite a brilliant appearance as they were illuminated for the first time by the electric light.

The Roxbury Gas Light Co. is moving in the matter of supplying electric light within its district as an auxiliary to its gas plant.

The Brookline Electric Light Co. have declared a 1½ per cent. dividend on a capital of $30,000.

The electric light company and the gas company in Waltham have been consolidated. A plant will be put in in an economical manner. The name of the gas company has been changed to that of the Waltham Gas and Electric Lighting Co.

The Newton Electric Light and Power Co. has been chartered. Horace B. Parker is president, and Herbert G. Pratt treasurer, and the capital stock is $20,000.

Captain Eldridge, of division 6, South Boston, has presented to the board of police a formal report of the work done by the patrol wagon connected with the Wilson municipal police alarm system. The figures contained in this report speak favorably for the police alarm system, which was placed in operation in division 6 last May for a practical test. The whole number of trips made by the patrol wagon from June 7th to Oct. 1st was 708. The greatest number of prisoners arrested by one officer by means of the patrol wagon was three; distance traveled by the wagon in making the 708 runs, 570 9-16 miles. With the new system the patrolmen have made more arrests than was the practice before. As a proof of this, there was in division 6 but 572 arrests during the months of July, August and September, 1885; and during the same months this year 711 arrests were made. On two occasions the patrol wagon went to the rescue of officers who had been attacked by friends of a prisoner.

The system has been in operation since June at no expense to the city, excepting the cost of maintaining two horses. No extra men have been employed, and while it was supposed at the outset that the services of a special operator would be needed to run the switchboard and telephone desk, it has been found that the officers themselves can run the switchboard satisfactorily. During the past forty days the system has been in the hands of the lieutenants and sergeants on duty in the office of station 6, and they have given thorough satisfaction to the commissioners. The question now is, will the city government adopt it?

BOSTON, October 16, 1886.

CHICAGO.

Work of the Great Storm of 12th-14th.—Annual Exposition at Chicago.—Electric Lights Exhibited.—A Marvelous New Telephone.

WHILE the Gulf storm was at its height on the 12th and 13th of October, another fierce blow was progressing from Dakota and Montana toward the more thickly settled portions of the northern states. The storm hereabouts reached its maximum on the 14th, when the wind from a south-westerly direction blew a thirty-mile hurricane, accompanied by a heavy downpouring of rain, during the early morning. The rain ceased about eight o'clock, but the wind kept at its work, laboring harder as the rain diminished, until by noon, when the highest velocity was reached, the recorded rate was thirty-six miles, while the barometer had reached the lowest limit ever recorded here, 29.098 inches. There was plenty of hustling after hats and umbrellas, and people entirely unused to that sort of thing were compelled to do some rather rapid time work, to recover fleeing property. Scaffolding went diving through space, and portions of chimneys, sections of cornices, as well as bricks and shingles, played tag through the air, to the imminent danger of pedestrians. Occasionally a window was wrecked, while trees, shrubbery, etc., especially in the parks on the west side, were badly crippled, and unfinished structures were especially trifled with by the wind fiend.

The most thoroughly broken up class of industry was the telegraph fraternity. Everything went to "eternal grand smash," everywhere. Only one patched wire was working to New York, on the night of the 14th, from the Western Union

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office here, and that was via Louisville, Cincinnati, and Philadelphia; the principal trouble being between here and Cleveland, and Toledo eastward through Detroit and Canada. Texas lines were all, of course, out of service, while southerly lines from here were in a very demoralized condition. The far west lines were all O. K. Just south of Chicago the tangle of wires was a gordian knot, and the managers say that they have just gone through the worst general wreck they have ever experienced. The Baltimore and Ohio company had also one patched wire to New York, via Cincinnati, Newark, O., and Baltimore. Their principal difficulty was between Fort Wayne and Cleveland, and east of Buffalo. They got along well until the storm struck Cleveland, about 8 P. M. The telephone company here have, they say, about one hundred cases of lines or instruments out of order, every day, while on the 14th the complaints were four times that number. Falling trees were the principal cause of trouble.

Towns on extra territorial lines suffered considerably, while the north-western part of the city was particularly affected. In place of twenty-five repairers who perform this sort of work under ordinary circumstances, one hundred and ten men were sent out, and the lines were soon in working order. From Galveston, New Orleans and the shores of the Mississippi, come stories of flood and great loss of life and property which are terrible in the extreme. Nearly one hundred persons were lost at the mouth of the Sabine river, the boundary between Texas and Louisiana.

Buffalo, N. Y., reported a terrific gale, the worst for years, on the 14th. The "island," between Buffalo river and the lake—a desolate, sandy tract—was covered with water, and the inhabitants, squatters, washed out by the huge waves. Twenty-nine houses were totally destroyed, and about 100 people left homeless just as winter is coming. The wind blew 65 miles per hour.

At Toledo there was quite a stir; wind, 50 miles an hour. Street signs, boxes, lamp-posts, trees, houses blown down, 25 unroofed, two street cars wrecked, five yachts blown ashore, dragging their anchors. The fire alarm wires were grounded by telephone lines, and rang an alarm for half an hour.

Our annual exposition closed on the 16th inst. The electrical showing was neither extensive nor varied. The Sperry company lighted the building, having both incandescent and arc lights—about 400 of the former, and nearly 100 of the latter. The Ball company exhibited 20 arc and a few incandescent lights on their own circuit—several of these on the engine driving-pulley—while upon another circuit several arc lights were run, as a cluster, by a gas engine. The Bain system was also exhibited by the Domestic Heating and Lighting Co., who showed both forms of light. Giles Brothers ran a couple of "three for a quarter" motors, to exemplify the efficiency of their shield in protecting the internals of a watch, "when the owner," as one of that class said the other day, "is obliged to be round the dynamo, and has either to run the risk of spoiling his watch if he wears it, or of having it stolen if he hangs it up. The shield is an antidote for both ills."

A new telephone has been patented by Mr. James Lowth, 742 West Congress street, Chicago. "It does not transmit air vibrations, but the vibrations of the vocal chords." If it could only carry the chords themselves, now!—but then, we can't expect to have the world in one patent: The description from the clear-headed reporter of one of our dailies is so complete that the readers of THE ELECTRICIAN AND ELECTRICAL ENGINEER should not be deprived of it:

"The first instrument Mr. Lowth made illustrated the principle of his telephone. This consisted of a round wooden box, about four inches in diameter, containing a set of electrodes, connected with a light wooden rod, passing out through a tubular handle. On the end of the rod is a small, light wooden button, which, held against the laryngeal surface, transmits the vibrations of the vocal chords that occur in speaking. The connection with the wires is made through an ordinary induction coil.

"The transmitter is, of course, the chief part of Mr. Lowth's invention. The receiver, which in the perfected instrument he has combined with the transmitter by means of a metallic yoke, is similar to the one in use in the Bell telephone. Mr. Lowth has a telephone in operation in his house, connecting the hallway with a rear room. In speaking through it the chief thing one notices is the difference in the timbre of the tone transmitted. The tone is much fuller and more characteristic than that carried through the older telephone. While the diaphragm instruments return a counter-wave of sound—an echo, in other words—this, the inventor explained, transmits directly muscular vibrations. There is, however, a cloudy quality to the tone, and, while the words are always loudly sent, there is often an indistinctness about them that baffles comprehension. The utility of the new instrument would seem to lie largely in its independence of accidental sounds. People talking near the telephone, the rattle of machinery, or sudden noises without, would not influence it in the least. Only the speaker's voice would be transmitted. For this reason, the instrument might be of value in many places where at present it is almost impossible to use a telephone."

CHICAGO, October 16, 1886.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICIAN AND ELECTRICAL ENGINEER, 115 *Nassau Street, New York city.*

REFORM IN THE PATENT SYSTEM.

[60.]—At the meeting of the National Electric Light Association, held in Detroit, in September, 1886, the subject of reform in the United States patent system was seriously discussed, and the legal committee directed to examine the question carefully during the coming winter, and report to the next meeting a plan, by which some of the evils that now exist may be rectified.

The duty imposed upon the committee is a heavy one, and at the same time freighted with great responsibility; and they naturally turn to the members of the association, and to the inventors and patent lawyers of the country for assistance.

The improvement of the patent system is a subject that is of the most vital importance to every one who owns patent property, and it is therefore with strong hope of their co-operation that this committee appeals to them for aid.

The first question that presents itself, is: What demands improvement? In answer to this, it is only necessary to say, both branches of the government system. The system under which patents are granted and the system under which they are litigated. The committee feel that in this country there are a large number of persons who have had much greater experience than they, in treating these questions, and they are satisfied that as all are working to a common end, the results they have in view would be greatly advanced, if they could receive the views and opinions of those who have given this question careful attention, and they would be deeply gratified if all those who are interested in patents and the administration of the patent system would consider the following questions carefully and write their views upon them.

1. What change would facilitate the examination of applications for patents?
2. What change would produce uniformity of practice in the patent office?
3. What change would enable an inventor to procure a patent which would be commensurate with his invention, rather than with the skill of his solicitors?
4. How can greater liberty and intelligence in the examination of patents by the courts be insured?
5. Under the rulings of the supreme and circuit courts of the United States, a patent is confined in its scope strictly to the letter of the claim, and it sometimes happens when a patent has been badly drawn that the patentee looses the benefit of his invention in consequence of this limitation. Is the present rule right or wrong, and if wrong what remedy would rectify the evil?

In answering these inquiries, correspondents are requested to address,

ARTHUR STEUART, Baltimore, Md.,
General Counsel of National Electric Light Association.

WIRE GAUGES.

[61.]—*Dear Sir*: I see that you are considering the wire gauge question. Your information as to the use of the new standard in England seems to be incomplete. We use no other gauge now, and it is legal in this country. It is in fact in use by all English administrations at home and abroad. At the same time the mode of indicating diameters in thousandths of an inch is very general and more practical in the case of electric light conductors; but all our manufacturers, I think without exception, use the gauge.

Yours, very truly, W. H. PREECE.

General Post-office, London, Sept. 24th, 1886.

LITERATURE.

RECENT PUBLICATIONS.

Fleming, J. A. Short Lectures to Electrical Artizans. Being a course of experimental lectures delivered to a practical audience. London: *E. & F. N. Spon* (New York, 35 Murray street), 1886. 208 p., illustr. 16mo.

Gariel, C. M. Traité Pratique D' Électricitné Comprenant les applications aux Sciences et a L' Industrie. Tome Second. Paris: *Octave Doin*, 1886. 552 p, 8vo.

Maier, Julius. Arc and Glow Lamps. A practical handbook on electric lighting. (The Specialist's Series.) New York: *D. Van Nostrand*, 1886. 375 p., illustr. 16mo.

Nipher, Francis E. Theory of Magnetic Measurements, with an appendix on the Method of Least Squares. New York: *D. Van Nostrand*, 1886. 94 p., 16mo.

CATALOGUES AND PAMPHLETS RECEIVED.

"Engineering," London, issues a neat and convenient directory of its current advertisements. In addition to a complete classification by trades, the directory contains an alphabetical list of advertisers, with their telegraphic addresses, followed by a "Key to Telegraphic Addresses."

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Messrs. Knudson & Ellsworth, 89 Nassau street, New York, send us a pamphlet containing many favorable notices, both foreign and domestic, of their acoustic telephones.

Mr. Willard E. Case, of Auburn, N. Y., has kindly sent us a copy of his paper on "A New Means of Converting Heat Energy into Electrical Energy," as communicated to the Royal Society through W. H. Preece, F. R. S.

The Edson Recording and Alarm Gauge Co., issue a descriptive and illustrated catalogue and price list of their electric recording gauges and speed indicators. It contains much interesting information concerning these useful appliances: and exemplifies their work by many fac similes of charts, taken in actual service by manufacturers and others using the gauges and indicators.

ELECTRICAL NEWS AND NOTES.

ELECTRIC LIGHT AND POWER.

A certificate of incorporation has been filed of the Baxter Electrical Manufacturing and Motor Co., of Baltimore city, with Benson M. Greene, James D. Mason, Jr., James F. Morrison, William Baxter, Jr., Wm. V. Logan, Leopold Strouse and Samuel Rosenthal, incorporators. Capital stock $200,000. The corporation is formed for the manufacture of implements and machinery for electric power, electric lighting, etc. The new company takes in the Morrison Electrical Works, Mr. J. F. Morrison accepting the presidency of the motor company. Plans are being made for extensive additions to the plant. Mr. T. McCoubray, former secretary of the Morrison Electrical Works, will be general business manager of the new company; Wm. Baxter, Jr., the electrician.

At Aurora, Ill., the common council has decided that it is more economical for the city to own and operate its own electric light plant, and voted to accept the bid of the Thomson-Houston company to put in a 60-lamp plant at a cost of $15,000.

An electric light plant of 50 arc lights is being put in at Steubenville, Ohio, by the Western Electric Co., of Chicago.

The Brush Electric Light Co. will have a four story building erected on Elizabeth street, New York, from plans of Mr. J. Ireland.

A 35 arc light plant of the Western Electric Co. is being put in at Crestline, Ohio.

It is reported that the Hartford Gas Light Co. and the Hartford Electric Light Co., have joined hands, and will be run under one management; the Gas company guaranteeing a dividend of six per cent. on the capital stock of the Electric company. The bargain is considered good for both parties.

We understand that the Rome Gas Light Co., Rome, N. Y., has put in an electric lighting plant.

It is reported from Columbus, O., that Mr. George L. Converse, Jr., has made a proposition to light that city by electric light. He proposes to furnish the city with 250 electric arc lights, properly tested and of 2,000-c. p. each, to be suspended at such street crossings or other places as the city council may direct, and to be lighted all night for the sum of $103 per year for each light and $100 per year for each additional light above that number. He also agrees to do commercial lighting at the same cost. The city may reserve the right to purchase the plant at an advance of fifteen per cent. above actual cost.

The managers of the Cyclorama of the battle of Gettysburg, have just closed a contract with the Ball Electric Light Co., of Boston, to put in an entire plant for lighting their building. They will put in a Ball 25 light dynamo, ten ampere current, a Southwark engine, and a Hodge steel boiler. The same company is installing a plant in Stoughton, Mass.

A system of electric light is contemplated at Mt. Vernon, Ohio. W. C. Culbertson, mayor, or S. H. Peterman, president city council, are gentlemen interested.

Torrington, Conn., will have an electric light plant, the capital of the company being $20,000.

NEW INCORPORATIONS.

The New England Electric Power and Light Co., Portland Me. Capital stock, $1,000,000. President, John E. May, Boston, Mass.

The Lord Acoustic Telephone Manufacturing Co., Portland, Me. Capital stock, $250,000. President, H. E. Townsend, 101 Mt. Vernon street, Boston, Mass.; treasurer, Henry Lunt, Quincy, Mass.

The Long Island City Electric Light Co., Long Island City, N. Y. Capital stock, $200,000. Augustus A. Levy, and others, incorporators.

The Iowa City Electric Light Co., Iowa City, Iowa, has been incorporated with a capital stock of $15,000. President, Moses Bloom.

PERSONAL MENTION.

Our long time associate Mr. R. W. Pope, has connected himself with the business of Mr. A. G. Day; having become associated with Mr. Clark B. Hotchkiss, general agent at 16 Dey street, New York.

Mr. Wm. H. Baker, who entered the service of the Western Union Telegraph Co., seventeen years ago, and has since that time been constantly associated in the telegraph and other electrical business, has recently carried out a long cherished desire, and was, on Sept. 30th, elected a member of the New York Stock Exchange. He has formed a connection with the house of R. J. Kimball & Co., 16 and 18 Wall street. Mr. Baker requires no introduction to electrical circles. We congratulate him on his favorable entrance to his chosen field, and wish him abundant success.

Mr. C. F. West, formerly superintendent of telegraph of the Mexican Central Railroad, has gone to Chicago, to act as Western representative of the Judkins Electric Railroad Signal Co.

MISCELLANEOUS.

The Union Switch and Signal Co., of Pittsburgh, will erect an addition to their works, to employ 300 more men.

The Standard Underground Cable Co., has contracted to supply the Western Union Telegraph Co., 8,500 feet of 24 conductor cable for their subway in Broadway.

The Standard company are now at work in Philadelphia, laying 3½ miles of underground cable for the Keystone Electric Light and Power Co.

ANNUAL REPORT

OF THE

PRESIDENT OF THE WESTERN UNION TELEGRAPH COMPANY

For the Year Ended June 30, 1886.

CAPITAL STOCK.

The capital stock of the company is $80,000,000, of which $20,969 belongs to and is in the treasury of the company. A small portion of the capital stock is still represented by certificates of indebtedness in the hands of the Union Trust Co., in trust for the parties entitled thereto.

In addition to the foregoing, there are outstanding certificates of indebtedness issued during the year, in lieu of cash dividends, to the amount of $1,199,852.06. These certificates are redeemable in capital stock, and bear interest at the rate at which dividends may be payable on the capital stock.

BONDED DEBT.

The bonded debt at the close of the year was as follows:—

Bonds due March 1st, 1900, 6 per cent	$901,044.00
Bonds due May 1st, 1900, 7 per cent	4,920,000.00
Bonds due May 1st, 1902, 7 per cent	1,373,000.00
	$7,194,044.00
Less balance of sinking funds, appropriations not yet used for redemption of bonds	366,834.11
	$6,827,209.89

During the year, sterling bonds due March 1st, 1900, to the amount of £2,100, were redeemed by the trustees of the sinking fund.

BUSINESS OF THE YEAR.

Surplus, July 1st, 1885		$4,324,004.11
The revenues, expenses and profits of the year ended June 30th, 1886, were as follows:—		
Revenues	$16,298,638.55	
Expenses	12,378,783.42	
Profits		3,919,855.13
		$8,243,859.24
From which there was applied		
For dividends	$3399,573.31	
" interest on bonds	494,461.40	
" sinking funds appropriations	39,991.00	
		3,934,025.71
Deducting which, leaves surplus, June 30th, 1886, of		$4,309,833.53

The expenses for the year were:—	
For operating and general expenses	$8,510,657.61
" rentals of leased lines	1,892,347.25
" maintenance and reconstruction	1,273,124.95
" taxes	499,592.30
" equipment of offices and wires	203,061.31
Total expenses, as above	$12,378,783.42

Whilst the volume of traffic has continued to increase, the tables show a material reduction in revenues, principally in the cable, gold and stock, and commercial news earnings. It will be remembered that for one-half of the previous year, the cable rates were fifty cents per word, with no competition; whilst during the year covered by the foregoing statement, there was active competition; and for a portion of the year cable business was done at the 12 cent rate, which had not been in operation long enough before the close of the year to develop the large increase

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in messages. Notwithstanding continued reductions in rates, the earnings from land lines service have been well maintained, the falling off in earnings from messages transmitted over the land lines being less than the increase from wire rentals.

There has also been a falling off in the revenues from dividends on stocks held by this company in telephone and other companies

The tables show an increase of 1,193,224 in the number of messages sent, and the increase in messages sent over rented wires, of which no account can be taken, must have been several millions more.

The average rate received for messages sent over the land lines operated by the company has been reduced to 30$\frac{3}{10}$ cents per message, whilst the average cost pertaining to the conduct of the business of the company in the transmission and delivery of messages, is reduced to a fraction under 24 cents per message; showing a reduction in the receipts of 1$\frac{3}{10}$ cents per message, and a reduction in the cost of handling messages precisely the same.

Of the increase of $373,000 in expenses, as compared with the previous year, $198,000 was in the item of taxes, $70,000 in line rentals, and the remainder almost entirely in cable repairs.

The closing table of the foregoing statement exhibits a general classification of what is charged to current expenses. Nothing is charged to construction but absolutely new property added to the plant.

GENERAL STATEMENT.

The following exhibit shows the revenues and disbursements of the company for twenty years from July 1st, 1866:—

Surplus of income acc't, July 1st, 1866...	$275,357.24	
Net revenues for twenty years, from July 1st, 1866, to June 30th, 1886.......	82,000,516.24	
Making an aggregate, June 30th, 1886, of............		$82,275,873.48

During this period there was applied:—

For cash dividends to stockholders.....	46,329,750.83	
For scrip dividend to stockholders......	1,199,852.06	
For cost of 59,606½ shares of Western Union Telegraph stock, purchased and owned by the company, which was distributed to stockholders in 1879..........	3,302,198.90	
For cost of 72,010 shares of Atlantic and Pacific Telegraph stock, purchased and owned by the company, the proceeds of which in Western Union stock were distributed to stockholders in 1881.....	1,806,250.00	
For interest paid on company's bonds...	8,190,264.49	
For cost of 396 44-100 shares of Western Union stock, purchased and owned by the company, which were canceled to make the capital stock, after the issue of the new stock in 1881, exactly $80,000,000..........	26,836.00	
For amount reserved for interest on bonds and for sinking funds, accrued to June 30th, but then not yet due and payable............	106,086.64	
		60,961,238.92
Leaving a surplus of............		$21,314,634.56

Which is represented as follows:—

Construction of new lines, erection of additional wires, patents, etc.	$9,396,160.08	
Purchase of telegraph lines and of the stocks of companies leased by the Western Union Co., upon which interest or dividends are paid as rental...	2,448,182.66	
Gold and Stock Telegraph Co.'s stock (18,905 shares)............	1,176,009.00	
International Ocean Telegraph Co.'s stock (15,170 shares)	961,606.42	
Brook's Underground Telegraph Co.'s stock (1,000 shares)..........	95,000.00	
Southern Bell Telephone and Telegraph Co.'s stock (1,687 shares)............	84,325.00	
Sundry other stocks and bonds..........	93,739.68	
Western Union bonds, redeemed and canceled............	1,400,089.27	
Sinking funds (portion not yet used for redemption of bonds, exclusive of interest allowed by trustees)............	320,352.82	
Broadway and Dey street building............ $2,365,639.52 Less amount provided from the proceeds of the bonds............ 1,802,202.00	563,437.52	
Real estate, other than above............	283,608.50	
Supplies and material on hand unissued.	182,290.08	
Surplus, June 30th, 1886............	4,309,833.53	
		21,314,634.56
On account of these assets, a stock distribution was declared in 1881, to the amount of		15,526,590.00
Deducting which, leaves a balance of...		$5,788,044.56

The above balance is the true surplus uncapitalized. It is nearly a million and a half larger than the surplus shown in the statement of current business, mainly because the sums paid for construction and new property in 1881 have been charged up in the current statements, and paid for out of earnings.

It will be seen by the first item in the foregoing statement that during twenty years since the removal of the company's headquarters to New York, the net revenues have averaged $4,100,000 per annum; of which there have been expended on an average $2,300,000 per annum for cash dividends to stockholders, $400,000 per annum for interest on bonds, and $1,400,000 per annum for construction and purchase of new property, not including any of the properties that were purchased for capital stock, except that portion of Atlantic & Pacific Telegraph Co. stock purchased, which was capitalized by the issue of stock dividends.

Of the $46,329,750,83 paid to stockholders in cash dividends during the past 20 years, as shown in the foregoing general statement, $25,195,823,49 have been paid in dividends since the consolidation of January, 1881; and in addition thereto $6,281,520.86 have been advanced and paid within the same period for new and additional properties—making an aggregate of $31,477,344.35 paid out of the net revenues of the company, over and above its fixed charges, since the date of its present capitalization, and within five and a half years.

From January 1st, 1881, to June 30th 1886, $7,281,520.86 were expended for construction and purchase of new lines, and for telegraph and telephone stocks, real estate and other new property. Of this, $1,225,915.22 (expended between January 1st, and September 30th, 1881) were appropriated out of the profits prior to October 1st, 1881; $1,000,000 were obtained by the sale of bonds to that amount; $1,199,852.06 were appropriated from the profits in lieu of which certificates of indebtedness were issued as dividend; and $3,855,753.58 have been advanced (since October 1st, 1881) from the surplus.

STATISTICS.

The following table exhibits the mileage of lines operated, number of offices, number of messages sent, receipts, expenses and profits, for each year since 1866.

Year.	Miles of poles and cables.	Miles of wire.	Offices.	Messages.	Receipts.	Expenses.	Profits.
					$	$	$
1866..	37,380	75,686	2,250	....			
1867..	46,270	85,291	2,565	5,879,282	6,568,925.36	3,944,005.63	2,624,919.73
1868..	50,183	97,594	3,219	6,404,595	7,004,560.19	4,362,849.32	2,641,710.87
1869..	52,099	104,584	3,607	7,934,933	7,316,918.30	4,568,116.85	2,748,801.45
1870..	54,109	112,191	3,972	9,157,646	7,138,737.96	4,910,772.42	2,227,965.54
1871..	56,032	121,151	4,606	10,646,077	7,637,448.85	5,104,787.19	2,532,661.66
1872..	62,033	137,190	5,237	12,444,499	8,457,095.77	5,666,863.16	2,790,232.61
1873..	65.757	154,472	5.740	14,456,832	9,333,018 51	6,575,055.82	2,757,962.69
1874..	71,585	175,735	6,188	16,329,256	9,262,653.98	6,755,733.83	2,506,920.15
1875..	72,833	179,496	6,565	17,153,710	9,564,574.60	6,335,414.77	3,229,157.83
1876..	73,532	183,832	7,072	18,729,567	10,034,983.66	6,635,473.69	3,399,509.97
1877..	76,955	194,323	7,500	21,158,941	9,812,352.61	6,672,224.94	3,140,127.67
1878..	81,002	206,202	8,014	23,918,894	9,861,355.23	6,309.812.53	3,551,542.70
1879..	82,987	211,566	8,534	25,070,106	10,960,640.46	6,160,200.37	4,800,440.09
1880..	85,645	233,534	9,077	29,215,509	12,782,894.53	6,948,956.74	5,833,937.79
1881..	110,340	327,171	10,737	32,500,000	14,393,543.85	8,485,264.18	5,908,279.72
1882..	131,060	374,368	12,068	38,842,247	17,114,165.92	9,996,095.92	7,118,070.00
1883..	144,294	432,726	12,917	41,181,177	19,454,902.98	11,794,553.40	7,660,349.58
1884..	145,037	450,571	13,761	42,076,226	19,632,939.60	13,022,503.90	6,610,435.70
1885..	147,500	462,283	14,184	42,096,583	17,706,833.71	12,005,909.58	5,700,924.13
1886..	151,832	489,607	15,142	43,289,807	16,298,638.55	12,378,783.42	3,919,855.13

The foregoing table exhibits the mileage of lines and wires after consolidating with the American and the United States Telegraph companies on the first of July, 1866; and the growth and increase of the property and business year by year for 20 years. Over 4,300 miles of pole line, over 27,000 miles of wire, and nearly 1,000 offices have been added to the plant during the current year. Of these additions, 1,800 miles of line and a little over 7,000 miles of wire were taken over from the American Rapid Telegraph Co., and 2,500 miles of line and 20,000 miles of wire have been newly constructed and paid for.

The construction account has been and continues to be unusually large. The rapid extension of railroads compels the extension of lines on new routes and in new territory, whilst the growing demand for private wires, the increase of messages and the exactions of prompt service have compelled the erection of additional wires in every part of the country, and especially on western routes. The outlay for new property has been very largely in excess of that for the previous year; and the demand for such outlay appears to be further increasing.

Notwithstanding that all the large press associations have

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leased wires, over which their standard daily reports are transmitted and distributed to all the principal towns and cities, of the amount of which no account has been taken, there have, in addition thereto been transmitted over wires operated directly by the company and delivered during the year, press reports to the amount of 438,912,332 words.

The table appended exhibits the assets in the treasury, as reported by a committee of the board after personal examination, showing few and immaterial changes from that of the previous year. A few railroad shares, bonds and scrip of small amounts which had been taken in payment for wires erected and for telegraph service, have been disposed of, whilst a few hundred shares of telephone stocks have been added, making an increase in the aggregate.

The outlook for the ensuing year is better. In the face of active and extended competition, and further reduced rates, the earnings are well maintained. The early moving of the grain crop made an active business in July and August, and the weekly returns from test offices showed a large increase of earnings; and some increase over those of corresponding weeks of the previous year is still exhibited. It has been demonstrated that, with two or more competitors reaching all the principal commercial centres east of the Rocky Mountains, and with some of the rates cut below the cost of the service, the company still maintains an earning capacity equal to more than four per cent. on its capital stock, above fixed charges.

Respectfully submitted,

October 13th, 1886. NORVIN GREEN, *President.*

The Wichita Gas Co. are so well satisfied with their electric lighting enterprise that they are increasing and adding another dynamo with a Westinghouse engine.

The Venezuela Telephone Company has, at Caracas, a telephone exchange of 500 lines, and uses the multiple switchboard of the Western Electric Company. Incandescent electric lamps are provided for the night operators, the Volta-Pavia batteries furnishing the electricity for the lamps.

A special despatch from Waupaca, Wis., dated Sept. 27th, says: An unusual electric display occurred here yesterday, during a severe thunder storm. The electric wires along Union street were so heavily charged with electricity that large balls of fire were suspended in the air just below them. Occasionally one would explode, and a number of persons in the vicinity received severe shocks.

AN IMPORTANT PATENT.

The patent issued to Messrs. Gaulard & Gibbs (No. 351,589, Oct. 26), for a method of electrical distribution and conversion, is of such interest that we print the claims below.

1. The hereinbefore-described art or method of electrical distribution and conversion, which consists in establishing in a closed electric circuit, a current of alternate and equal positive and negative potential, producing by the influence of such current an inductive field of alternate polarity, and thereby inducing in translating devices situated in an independent closed circuit traversing such field, a similar alternating secondary current of greater quantity and less potential than the originating or producing current.

2. In a system of electrical distribution, an inductorium or converter, in which the length of that portion of the conductor traversed by the primary current within the magnetic field created by itself, exceeds the length within the same field of the conductor traversed by the secondary current, in combination with a dynamo-electric generator producing alternating electric currents or pulsations of equal potential and duration, and translating devices actuated by said secondary current.

3. In a system of electrical distribution, an inductorium or converter, in which the resistance of that portion of the conductor traversed by the primary current within the magnetic field created by itself, exceeds the resistance of that portion of the conductor traversed by the secondary current which lies within said field, in combination with a dynamo-electric generator producing alternating currents or pulsations of equal potential and duration, and translating devices actuated by said secondary current.

4. In a system of electrical distribution, a dynamo-electric machine, organized for the production of alternate positive and negative currents, equal to each other in potential and duration, in combination with the primary circuit of an inductorium or converter organized to induce in its secondary circuit alternating currents of lower potential and greater quantity than those of the primary circuit, and one or more translating devices actuated by said secondary currents.

5. In a system of electrical distribution, the combination of an inductorium or converter, having its primary and secondary circuits constantly closed, a dynamo-electric generator for producing alternating currents of equal potential and duration included in said closed primary circuit, and one or more translating devices included in said closed secondary circuit, substantially as set forth.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICIAN AND ELECTRICAL ENGINEER, *by* Pope & Edgecomb, *Solicitors of Patents for Electrical Inventions,* 11 *Wall Street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From September 21st to October 12th 1886 (inclusive).

Alarms and Signals:—*Annunciators,* John Geary, 349,579 and 349,580, September 21; C. A. Tucker, 350,449, October 5. *Electric Fire Extinguishing and Alarm System,* J. W. Frost, 350,126. *Automatic Electric Fire Alarm System,* J. W. Frost and S. D. Lake, 350,426, October 5. *Universal Electric Damper and Fire Alarm,* E. A. Morley, 350,548. *Hotel Call, Fire-Alarm and Indicator,* A. T. Hess and H. A. Stoltenberg, 350,626. *Signaling Apparatus for Police-Telegraphs,* L. H. McCullough, 350,684. *Fire-Alarm Telegraph System,* S. A. Chase, 350,804. *Multiple Call-Box,* C. Herrmann, 350,882, October 12.

Clocks:—*Electric Clock,* D. T. Garcia, 349,879, September 28. *Primary Electric Clock,* C. A. Hussey, 350,431. *Secondary Electric Clock,* same, 350,433. *Case for Secondary Clock,* same, 350,435, October 5. *Electro-Mechanical Synchronizer for Clocks,* J. H. Gerry, 349,493. *Pneumatic-Mechanical Synchronizer for Clocks,* J. H. Gerry and M. E. Hunter, 349,494. *Electric Programme-Clock,* A. J. Reams, 349,605. *Electric Synchronizer for Clocks,* M. E. Hunter and J. H. Gerry, 349,650, September 21. *Electric Winding Device for Clocks,* W. F. Weisgerber and I. C. Himmer, 350,177. *Electric Time-Indicating System,* C. A. Hussey, 350,430, 350,432 and 350,434, October 5.

Conductors, Insulators, Supports and Systems:—*Underground Conduit,* J. C. Anderson, 349,472, September 21. *Underground Conduit for Electrical Conductors,* C. G. Perkins, 349,739. *Electric Subway,* J. M. Jagel, 349,797. *Insulator,* N. T. Fitch, 349,788. *Insulator for Electrical Conductors,* S. F. McGill, 349,893, September 28. *Insulating Clamp for Electric Wires,* J. W. Holdsworth, 350,365, October 12. *Underground Electrical Cable,* B. Williams, 350,515. *Machine for Manufacturing Insulator Pins for Telegraphic Purposes,* C. Rogers, 350,843, October 12.

Dynamos and Motors:—*Dynamo-Electric Machine,* E. T. and D. Higham, 349,716; J. Jenkins, 350,000; R. Kennedy, 350,003. *Compound-Wound Dynamo-Electric Machine,* E. Thomson, 349,912, September 28. *Electric Generator,* W. Stanley, Jr., 349,615, September 21. *Electric Motor,* A. Bossard, 349,-563; V. E. Keegan, 349,654, September 21; E. T. and D. Higham, 349,715; R. Vogler, 350,025, September 28; P. Diehl, 350,668, October 12. *Electric Motor and Generator,* W. Hansell, 349,392, September 21. *Electric Motor or Generator,* F. E. Fisher, 350,726, October 12. *Belt Controller for Dynamo Machines,* B. F. Radford, 350,154, October 5. *Regulator for Dynamo-Electric Machines,* O. P. Loomis and H. W. Cooley, 350,754. *Machine for Winding Armatures,* L. B. Jones, 350,828, October 12.

Galvanic Batteries:—*Electric Battery,* E. Bazin, 349,880, September 21; H. B. Cox, 350,294, October 5. *Galvanic Battery,* C. E. Piper, 349,600, September 21. *Galvanic Battery Cell,* L. Drescher, 350,621, October 12. *Utilization of the Residual Liquids from Batteries,* L. A. W. Desruelles, 350,296. *Protective Coating for the Electrodes of Batteries,* same, 350,297, October 5.

Ignition:—*Electric Gas Burner,* A. T. Smith, 349,533, September 21.

Lamps and Appurtenances:—*Electric Arc Light,* G. M. Lane, 350,140, October 5. *Electrolier,* C. G. Perkins, 349,516. *Manufacture of Incandescents,* R. Dick, 349,572. *Automatic Cut-Out for Electric Light Circuits,* W. Stanley, Jr., 349,613 and 349,614, September 21. *Electric Arc Lamp Protector,* G. Jeffery, 349,999. *Electric Lamp Post,* H. M. Doubleday and J. Lyman, 350,-046, September 28. *Electric Lighting System,* P. Diehl, 350,482. *Cut-Out for Electric Lamps,* L. G. Woolley, 350,519. *Safety Cut-Out for Electric Circuits,* E. R. Whitney, 350,648, October 12. *Insulating Coupling for Combined Electric Light and Gas Fixtures,* C. S. Forsyth, 350,855, October 5.

Metallurgy:—*Magnetic Separator,* C. O. Bartlett, 349,422, September 21.

Miscellaneous:—*Coupling for Electric Wires,* J. A. Lantz, 349,397 and 349,-398. *Induction Coil,* W. Stanley, Jr., 349,611, 349,612, 349,616 and 349,617, September 21. *Check or Ticket Register Apparatus,* J. H. Guest, 349,710. *Coupling Device for Electrical Conductors,* C. G. Perkins, 349,809. *Call Bell Switch,* L. Townsend, 350,024, September 28. *Electric Water-Level Indicator,* C. H. Wiekersham, 350,279. *Electric Bell-Cord,* H. B. Cox, 350,293. *Door Catch Adapted to be Operated by Electricity,* W. H. Markland, 350,312. *Detector for Marsh and other Hydrocarbon Gases,* N. W. Perry, 350,388. *Apparatus for Vaporizing Liquids,* E. B. Potter, 350,445. *Case for Medicine Bottles,* C. A. Tucker, 350,450. *Appliance for Closing Openings in Buildings Automatically,* C. A. Tucker, 350,451, October 5. *Apparatus for Protecting Safes and Vaults,* J. Fleckinger, 350,823. *Junction Clamp for Electric Wires,* L. B. Jones, 350,829. *Constant-Potential Regulator,* C. Hering, 350,676, October 12.

Railways and Appliances:—*Electric Railway Signal,* W. Daves, 349,927, September 28; P. J. Wicks, 350,790, October 12. *System of Railway Signaling,* T. A. Edison and E. T. Gilliland, 350,234, October 5. *Car-Brake,* H. S. Park, 349,738. *Circuit-Closer for Rails,* W. Daves, 349,926, September 28. *Railway Telegraphy,* T. A. Edison and E. T. Gilliland, 350,235. *Automatic Circuit-Closer for Railway Signals,* W. Buck, 350,411, October 5.

Telegraphs:—*Quadruplex Telegraph,* W. Maver, Jr., 349,945, September 28. *Automatic Telegraphy,* J. H. Robertson, 350,320. *Mode of Electric Communication,* A. E. Dolbear, 350,299, October 5. *Printing Telegraph,* D. B. Scott, 350,469, October 5. C. L. Buckingham, 350,615, 350,616 and 350,617, October 12. *Transmitter and Sounder,* G. W. Stewart, 350,644, October 12.

Telephones, Systems and Apparatus:—*Telephone Transmitter,* F. G. Sargent, 350,215, October 5; G. L. Roberts, 350,772, October 12. *Telephone Receiver,* L. S. Fairbanks, 349,575, September 21. *Telephone Circuit,* W. Marshall, 349,312, September 21. *Telephonic Apparatus,* P. Gannon, 349,839. *Telephone Switch,* J. F. Mehren, 349,947. *Automatic Telephone-Exchange System,* J. H. Bickford, 349,975 and 349,976, September 28. *Induction Coil for Telephone Service,* E. B. Hamlin, 350,130. *Telephonic Apparatus,* J. W. Lee, 350,160. *Telephone Attachment,* J. T. Lister, 350,203, October 5. *Automatic Telephone Call,* C. F. Willis, 350,610. *Telephone Circuit,* J. A. Barrett, 350,715. *Telephone Trumpet,* E. L. Hall, 350,737, October 12. *Telephone Time Register,* J. W. Tabony, 349,539, September 21.

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THE ELECTRICIAN
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Conducted by F. L. POPE. G. M. PHELPS, JR., R. W. POPE, } Associate Editors.

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NEW YORK, DECEMBER, 1886.

THREE YEARS OF TELEGRAPHIC COMPETITION.

IT needs but a superficial analysis of the figures contained in the annual report of the Western Union Telegraph Company in our last issue, to show that the competition with which it is now meeting from its rivals, is incomparably more damaging in respect to the inroads made upon its revenue, than any which it has encountered at any time in its past history. The profits of the last fiscal year were actually less than in any preceding year since 1878. It is perfectly obvious that this result is almost wholly due to the absurdly low tariffs between prominent points, which have for some time prevailed. It appears from the report that the average amount received for tolls on the land lines operated is now 30.9 cents per message, while the average cost is a fraction under 24 cents per message. Assuming these figures to be correct, it is not difficult to form some conjecture of the losses which are incurred in the transmission of messages between the principal commercial centres at rates of 20, 15 and in some instances even 10 cents. The total number of messages transmitted during the year was 43,289,807. It is apparent, therefore, that an increase in the gross receipts of only five cents on each message transmitted would have augmented the profits of the year no less than $2,164,490, an amount which would have enabled a six per cent. dividend to be paid without difficulty with the present traffic.

If the Western Union company is suffering severe losses on a large share of their business at present prices, it is difficult to see how their competitors can fail to fare even worse, as their lines do not reach nearly so large a proportion of non-competitive points where former rates are still maintained. It is clear that a considerably larger percentage of the entire business of the competing companies than of the Western Union, must be done at a loss, inasmuch as it is not easy to see how the cost per message in their case can be reduced much below that of their rival. The principal item of the expense account, that of labor, must be about the same in one case as the other.

An analysis of the results of the business of the Western Union company for the past 20 years, as tabulated in the report, discloses some interesting and noteworthy facts. In 1866, the present corporation was formed by the consolidation of the original Western Union and the American and the United States Telegraph companies, with a capital in round numbers of $41,000,000. With the exception of a slight falling off in 1870 and again in 1874 and 1877, the latter however, being apparent only, and due to the abnormally large business of the preceding year, the gross earnings show a progressive and quite uniform increase up to the end of the fiscal year 1878. The net earnings, owing to frequent reductions in the tariffs, did not keep pace with the gross receipts, but nevertheless averaged more than six per cent. on the capital from 1866 to 1877. The phenomenal increase from this time forward in the net earnings which rose from $3,140,127.67 in 1877, to $5,908,279.72 in 1881, shows that the increase of the capital stock to $80,000,000, upon the absorption of the American Union and Atlantic and Pacific lines, in 1881, was a measure by no means unwarranted by the condition and prospects of the business. The profits in 1880 and 1881 show that the earning capacity of the system was much more than sufficient to pay six per cent dividends on the enlarged capital. The period of prosperity in the affairs of the company, which commenced in 1878, continued without intermission until 1883, the receipts showing a progressive, uniform and unprecedentedly rapid increase from year to year, the expenses meantime averaging something like 60 per cent. of the receipts. If this state of affairs had remained undisturbed by competition, the same progressive rate of gross income and percentage of operating expenses would have brought the earnings in 1886 to about $25,000,000, the expenses to about $15,000,000, and the profits to nearly or quite $10,000,000, which would have been nearly enough to pay 12 per cent. per annum on the present capitalization. But in 1883, trouble commenced. First came the strike among the employés, which cost half a million dollars in extraordinary expenses, and at least a million more in loss of revenue. Then Mr. Garrett, who had apparently taken a lesson from Mr. Gould's American Union book, began to extend the Baltimore and Ohio system, and to cut the rates. As a result, the totals of the year 1884 show that while the progressive increase in gross receipts had been almost checked, the increase in expenses had gone on at the ordinary rate, and, of course, the profits had materially fallen off. The decline in the gross earnings of the company since 1884 has been as rapid as their preceding growth, while the falling off in net earnings has been still more rapid, these last having in fact diminished nearly one-half within the last three years.

The results of this analysis would seem to point to but one conclusion. The day cannot be far distant when some arrangement must of necessity be entered into with the Western Union company by its competitors, whereby the rates shall be advanced to a remunerative figure. It may be done by consolidation; by pooling the receipts and

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expenses upon a percentage basis, or it may perhaps be effected by a simple agreement as to tariffs between the several competitors.

It is wholly improbable that the competitors of the Western Union company will be able to inflict any greater damage upon its revenues in future than they have done during the past year, while at the same time it will be seen that even under these conditions its net earnings have not gone below four per cent upon its present capital. As Western Union is well known to be controlled by a small group of strong capitalists, of whom Mr. Gould is the chief, there is no apparent reason why those astute gentlemen cannot if they choose, afford to let the present condition of affairs go on indefinitely, or until their competitors are exhausted, and then take them in upon some basis which will be remunerative to themselves. Such a consummation must necessarily result in a restoration of the rates to a reasonable and remunerative figure, but we have already shown that such an increase would, as far as the public is concerned, amount to but a trifling sum on each message transmitted.

For our own part, we think that the same result might probably be reached in another and more satisfactory way, and that is by adopting a tariff scale similar to that which has proved so successful in Great Britain. Suppose a minimum 10 word rate of 20 cents for all distances were adopted, address and signature to be counted and paid for, and words in excess to be charged two cents each. Let a moderate yearly charge be made for registering addresses and furnishing a code address as is now done in the cable service. The result would be that every word sent over the lines would be paid for. Every customer would find it to his advantage to make his messages as brief as possible, whereas under the present system he often avails himself of his entire 10 words to say what might be said in one, in order to be sure he gets the worth of his money. The adoption of such a system would virtually be a continuance of low rates as far as the public is concerned, accompanied by a material increase in the proportionate revenues of the telegraph service. This matter is worthy of the serious attention of our leading telegraph companies, and we wish it might receive it. We shall have more to say on this subject on a future occasion.

In another part of this issue, we print a graphic diagram, showing the business of the Western Union company for the past 20 years which will be found of interest.

ELECTRICITY THE ILLUMINANT, AND GAS THE FUEL, OF THE FUTURE.

NOTHING is more remarkable and apparently more unaccountable than the fact that great improvements often seem to keep abreast of each other in the march of civilization. In referring in our last number to a recently perfected system of electrical distribution by induction, we suggested that the problem of the economical distribution of electricity over the areas practically required in electric lighting had probably received its final solution, and that if this turned out to be the case, the displacement of the existing illuminating gas system by incandescent electric light plants could be but a question of a few years time. It seems an extraordinary coincidence that just at the very time that the progress of invention in one field of research has reached a point indicating that it is the manifest destiny of electricity to become the universal illuminant of the future, the progress of invention in another and wholly different direction points out with no less distinctness, that gas is to be the universal fuel of the future.

When the managers of the existing illuminating gas companies were for the first time reluctantly compelled to contemplate the possibility of a revolution in the time-honored methods of heating and lighting, to which we have become so accustomed that they seem a part of the inevitable order of things, it was at once perceived by them that even were the methods of manufacturing fuel-gas all that could be desired, yet the capacity of the existing pipe systems was far too small to convey the much greater volume of gas necessary for fuel consumption. Now, however, when the gas companies are brought face to face with the emergency they have so long dreaded, a most unexpected source of relief has presented itself for their consideration. The public is tolerably familiar with the fact that natural gas has been employed for manufacturing and domestic purposes for some three or four years in Pittsburg, and several adjacent towns and cities, but few are aware of the enormous extent of the service, and still less are they familiar with the perfection to which the appliances for transporting, controlling and regulating this volatile fuel has been brought by the well directed labors of the inventor.

A recent report in the *American Manufacturer* shows that 470 manufactories and over 5,000 dwellings in the city of Pittsburg alone have been provided with a supply of fuel-gas by a single company within a little over three years. The entire Pittsburg system comprises over 500 miles of pipe of different sizes, supplied from 107 gas wells at a pressure sometimes reaching 500 pounds per square inch. This enormous pressure is automatically reduced at the point of consumption by suitable appliances to two or three ounces per square inch, in fact to about the same pressure at which illuminating gas is ordinarily distributed. This extensive practical use of apparatus for safety and control, is quite sufficient to demonstrate its applicability to ordinary gas systems, so that it is apparent by simply increasing the pressure and applying the necessary automatic controlling and regulating devices, the capacity of the existing illuminating systems will be found amply sufficient to convey and distribute the required supply of fuel-gas. As to the vital matter of cost, it is well ascertained that fuel-gas can be manufactured and supplied to the consumer at a less price per unit of heat than he now pays for coal, leaving at the same time a handsome profit to the manufacturer. We may doubtless expect within a few years to see the vast heaps of refuse coal and coal dust which encumber the earth in the mining regions of Pennsylvania utilized for this purpose. Thus it would seem that the ceaseless progress of invention has opportunely provided a way in which the present illuminating gas companies can utilize their extensive and costly plant in a manner perhaps even more profitable than they have heretofore done, while at the same time they may add an electric plant to their outfit, and thus be in a position to supply fuel, light and power, to consumers at a tempting profit upon the entire

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capital invested. In short, the present indications are that in respect to our methods of producing and distributing heat, light and power, we are on the eve of a complete industrial revolution, the beneficial consequences of which are so vast as to defy calculation or prophecy, for, as it has been well said "fuel is the main-spring of modern civilization."

THE PAN-ELECTRIC GOVERNMENT SUIT.

The attempt to break down the Bell telephone patent by a resort to the extraordinary and questionable method adopted by the United States government, at the instigation of Pan-Electric and other speculators has again met with disaster.

The decision of the United States Circuit Court at Cincinnati, noted in our news columns, fully sustains the contention of the American Bell Telephone Company in their plea to the jurisdiction, and dismisses the suit so far as that company is concerned. It does not seem likely that a continuance of the proceedings against the remaining defendants—the local telephone companies in Ohio—would result in any progress towards the object of the suit, the cancellation of the Bell patent.

The government is thought to be averse to bringing suit in Massachusetts, and under the Cincinnati decision it can reach the owners of the patent nowhere else. If suit were begun there it could hardly be brought to a hearing before the presentation of the entire group of telephone cases now advanced on the docket of the United States Supreme Court for early hearing.

It is understood that all questions raised in the Pan-Electric government suit are included in the cases made up for the Supreme Court. It seems to us a matter for congratulation that the validity of the Bell telephone patent is likely to be first passed upon by the Supreme Court through normal and regular proceedings.

Whatever the result reached by the Supreme Court on the merits of the case, it will always be a subject of regret on the part of lovers of purity in government, that the legal machinery of the United States was directed against a great business interest, through unaccustomed channels, and at the incitement of a body of speculators, including among their number the very head of the legal department of the government.

THE EDISON INCANDESCENT LAMP PATENTS.

The Edison Electric Light Company have recently issued a handsome pamphlet setting forth at length the claims of priority in behalf of Mr. Edison to the essential features of the modern incandescent electric lamp. Although apparently primarily intended to be placed in the hands of parties using or proposing to use incandescent lamps furnished by other makers, yet the contents of the publication are of such interest and importance to all interested in the general subject of electric lighting, and moreover as it is an authentic and complete presentation of Mr. Edison's case, we trust no apology is necessary for placing it in full before our readers, which we do in another part of the present issue.

It would be out of place to discuss, in advance of an adjudication by the courts, the various claims of infringement which are made against divers prominent incandescent lamps now in the market, but it may perhaps be admissable to direct attention in this connection to an article published in the Electrician and Electrical Engineer, volume iv, page 244, in which it is shown by evidence, apparently conclusive, and which at least has never been denied, that the three principal lamp patents relied on by the Edison company (numbers 223,898, 227,229 and 265,777), have expired by the operation of statute, and are now public property. The presumably complete list which is given of United States patents belonging to the Edison Electric Light Company, will be found convenient for reference.

The intimation which is conveyed to persons using incandescent lamps other than the Edison, that in the predicted event of rival corporations becoming pecuniarily irresponsible and unable to protect their customers from an "avalanche of damages" coupled with the statement that "a conservative calculation apportions the damage of $25 for each lamp in an original installation and $2.50 for each renewal lamp," appears to us of somewhat doubtful propriety, and one which would hardly seem to be likely to redound to the ultimate advantage of the party making it. The fact that certain patents have been sustained in Germany and England, of course, affords no presumption whatever that a like result will follow in the United States.

THE BELL TELEPHONE ANTICIPATED AGAIN.

We are somewhat surprised to find the name of Royal E. House, who won such merited distinction through his printing telegraph invention nearly 40 years ago, added to the now rather numerous list of claimants to priority in the invention of the telephone. In an illustrated article on the House patent, No. 77,882, of 1868, for an "Improvement in Electro-phonetic Telegraphs," the *Scientific American* of November 13, claims the invention to be a speaking telephone. Upon examination of the patent and comparison of its drawings and specifications with the text and illustrations of the article under notice, the conclusion of the *Scientific American* seems far fetched, to say the least. The patent shows a very sensitive sounder adapted, by means of a sound-board and resonator, to amplify the sound of blows from an armature and lever, playing between adjustable limiting pins attached to the sound board: there is not a word of any other use intended or thought of. The alterations of the sounder, in structure and function of parts, involved in the description and illustrations of the *Scientific American*, and necessary to make it operative as a telephone, are clearly suggestions borrowed from later inventions.

We should have stated in our last issue, that the very interesting article therein by Mr. Hermann Lemp, on "The Distribution of Arc and Incandescent Lights on the Same Circuit," was prepared and in hand in time for our June number, but was withheld from publication, at the suggestion of the chief counsel of the Schuyler Electric Light Co., on account of the pendency of certain patents.

The Title and Index for the volume of this journal closing with the present number will be supplied with the January number. Any subscribers discontinuing with the present number will be supplied with Title and Index upon notice to the Publishers.

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ARTICLES.

ON A METHOD OF REGISTERING SMALL VARIATIONS OF SPEED, AND DETERMINING THE ABSOLUTE NUMBER OF REVOLUTIONS OF AN ENGINE OR OTHER RUNNING MACHINERY.[1]

BY PROF. WM. A. ANTHONY.

During some experiments upon electric currents furnished by dynamos, it became necessary to determine and record the small variations of speed of the engine. Speed counters, giving as they do only the total number of revolutions in a given time, were useless, not only for that reason, but because they could not be used with sufficient accuracy to indicate the small variations. The centrifugal speed indicators at hand, were not sensitive enough to answer the purpose. What was wanted was a continuous record by an instrument of such delicacy that the smallest changes should be plainly indicated. The method which it is the object of this paper to describe may be best understood by supposing the engine, or other machine, whose speed it is desired to record, to take the place of the driving mechanism of the ordinary cylinder chronograph used for astronomical purposes. The engine may be so geared to the cylinder that the latter shall, when the engine is running at its normal speed, make one revolution per minute, or one revolution in any whole number of seconds, as may be desired. It is evident that, if the engine run continuously at its normal speed, the notches indicating the seconds in the chronograph record, will form straight lines parallel to the elements of the cylinder. If the speed vary from the normal, these lines will form an angle with the elements of the cylinder and this angle will change for every variation in the speed.

Let c = circumference of the cylinder.

d = longitudinal movement of pen for one revolution of cylinder.

a = number of revolutions of engine to one of cylinder.

x = number of revolutions per minute.

Suppose the clock to make a record every two seconds, and let these records fall in n lines on the chronograph sheet. If these lines make with the elements of the cylinder an angle θ, a point on the circumference of the cylinder moves in the time that elapses between a given record and the next in the same line, a distance $c + d \tan \theta$. Hence the distance traversed in one second is

$$\frac{c + d \times \tan \theta}{2n} = \frac{xc}{60a}.$$

Hence

$$x = \frac{30a}{n}\left(1 + \frac{d}{c} \tan \theta\right).$$

If θ is zero

$$x = \frac{30a}{n}$$

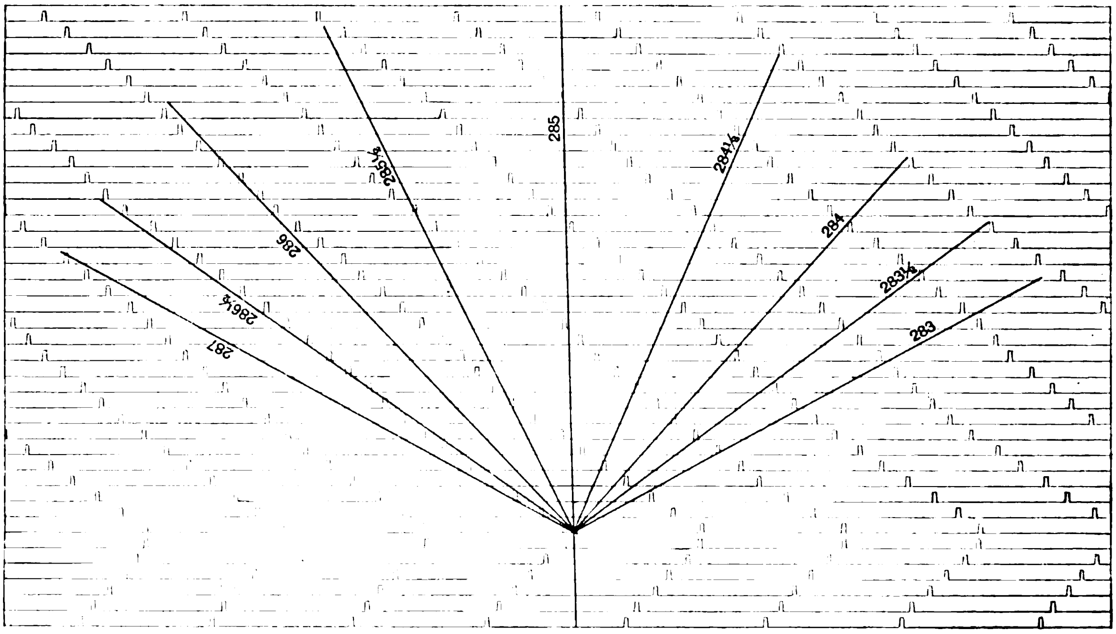
Represent this value, which was assumed as the normal speed of the engine, by b, then

$$x = b\left(1 + \frac{d}{c} \tan \theta\right)$$

$$\text{and } x - b = \frac{db}{c} \tan \theta.$$

Putting $x - b = 1$, we may find the value of θ' corresponding to a change of one revolution in the rate of the engine.

$$\tan \theta' = \frac{c}{db}.$$



As the apparatus was used at the Cornell University when the accompanying records were made, the values of the constants were as follows :— c, 21 3-4ths inches ; d, 1-12th inch ; b, 285 revolutions ; a, 285 ; n, 30. The formula for x is, therefore,

$$x = 285\ (1 + .00383 \tan \theta).$$

The angle θ' corresponding to a variation of one revolution from the normal speed is

$$\tan^{-1} = .9158, \text{ about } 42\tfrac{1}{2} \text{ degrees.}$$

It is plain from the above that the sensitiveness of the instrument is increased by making c large or d small.

The indications of the instrument are not changed by changing the relation between the speed of the cylinder and engine so long as that relation is such that the record appears in straight lines parallel to the axis of the cylinder for the same normal speed, b. This relation is only important when the speed of the engine is subject to rapid fluctuations. To show such fluctuations, the cylinder must be made to revolve rapidly, reducing the number n, of lines in the record.

This method of recording speed is especially valuable in connection with the modern high speed engines and with dynamo machines where any considerable change of speed would be inadmissible. In constructing an apparatus

1. Read before the Buffalo Meeting of the American Association for the Advancement of Science, August, 1886.

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expressly for it, the ratio of *c* to *d* might be made 100, when a change in speed of one per cent. would be represented by an angle of forty-five degrees. In a shop or factory an apparatus might be improvised for the purpose, by mounting a cylinder in a lathe and attaching the recording mechanism to the slide-rest.

In the figure, which is a portion of an actual record, the greatest change of speed, as will be seen by the lines which show the angles corresponding to the different speeds, was two revolutions per minute, or less than one per cent. It was caused by throwing off the entire load, 18 h. p., leaving the engine running light.

PHYSICAL LABORATORY,
CORNELL UNIVERSITY, ITHACA, N. Y., August, 1886.

NOTE.—Since the above paper was read the same apparatus has, by a slight modification, been arranged to test the slip of belts and friction clutches. This can best be explained by an illustration. Suppose it is desired to determine the slip of the main belt of the engine. The chronograph cylinder is driven by the engine as described in the paper, but the pen, instead of being operated from the standard clock, is actuated by a break circuit driven by the shaft which the main belt drives. The speed of the break circuit is in such relation to that of the shaft that if the belt drives without slip, the chronograph records appear in straight lines parallel to the axis of the cylinder. The character of this record will remain unchanged so long as the engine and shaft maintain the same *relative* speed, but if, upon throwing a load on the shaft the belt slip, it will at once be indicated by the chronograph record assuming an oblique line.

PHYSICAL LABORATORY,
CORNELL UNIVERSITY, ITHACA, N. Y., Nov. 16, 1886.

A RELATION BETWEEN MAGNETIZING FORCE AND CORE OF MAGNET.

BY E. L. FRENCH, B. S.

THE following account of an experiment, carried on by me at the Physical Laboratory of Cornell University, may prove interesting to some readers of THE ELECTRICIAN AND ELECTRICAL ENGINEER.

It has seemed to me that a formula which would enable a man to state the greatest number of ampere turns that

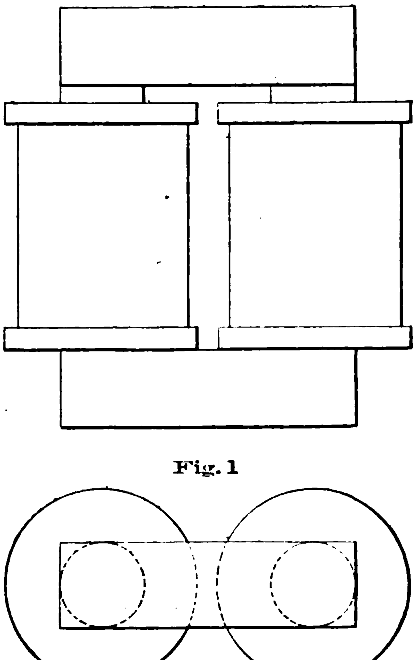

Fig. 1

could be used economically on a core of given size, might have some practical value. By "economical" use, I mean that the strength of the magnet increases rapidly per ampere, up to this number of turns, in comparison to what the increase is with a little greater number. It will be seen later that we cannot say exactly what this number is, since the bends in the saturation curves are not sharp ones.

The scheme of the experiment was as follows: To find the highest economical number of ampere turns for each of several electro-magnets, all of same type and material, and having cores whose diameters increase regularly by a small amount. To decide what was the highest economical current for each magnet (the turns being constant), by plotting a curve whose ordinates are proportional to strength of magnet, and abscissæ are proportional to amperes of current. Finally, to take these "highest economical currents" in amperes, and their corresponding diameter of core in centimetres, and plot them for a final curve. The equation of this last curve will furnish a formula which gives us the diameter of core, when ampere turns are known, or gives the ampere turns when the diameter is known—provided the material and type is the same as in those magnets experimented upon. The type of magnet used is shown in figure 1, which gives plan and elevation. The cores are of circular cross-section, and the armatures of square. Each edge of the cross-section of armature equals the diameter of its corresponding core. Five such cores, with their armatures, were made from patent cold-rolled shafting, presented to the university by Jones & Laughlins, of Pittsburg, Pa., and used in a set of spools which would just admit of the largest core, as will be seen by the table of dimensions below:—

SPOOLS.			
Internal diameter of tube.	Thickness of tube (brass).	Wire.	No. turns on each spool.
6.34 cm.	About 2 cm.	No. 10 copper wire, single wound, run through paraffine.	785

CORES.		ARMATURE.	
Diameter.	Length.	Section.	Length.
1.22 cm.	20.85 cm.	1.22 × 1.22 cm.	18.3 cm.
1.22	20.85	1.22 × 1.22	18.3
2.52	20.88	2.52 × 2.46	19.62
2.52	20.88	2.54 × 2.46	19.62
3.76	20.82	3.80 × 3.74	20.90
3.76	20.82	3.80 × 3.74	20.90
5.03	20.82	5.10 × 5.02	22.04
5.03	20.82	5.10 × 5.02	22.04
6.34	20.88	6.32 × 6.30	23.90
6.34	20.88	6.36 × 6.30	23.92

Armatures of section 2.52 × 2.46 and 2.54 × 2.46 were steel, Jones & Laughlins not having the cold-rolled shafting on hand. The extreme length of the spools was about

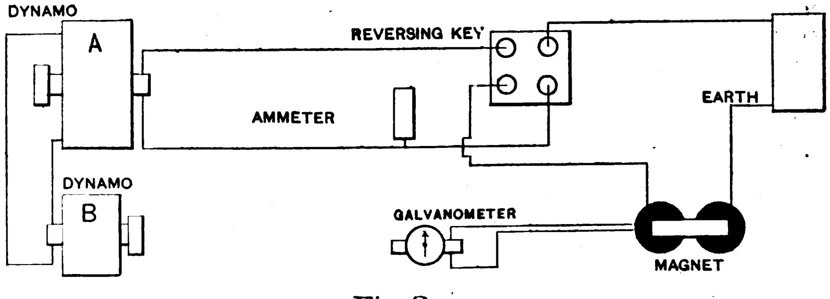

Fig. 2

1 cm. less than the length of cores, to admit placing a narrow coil of fine wire close around the pole above the spool. The surfaces of the armatures were planed smooth and the ends of cores squared off (in a lathe) at the Sibley college shops.

In all tests made by me, the magnets were set up as

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shown in figure 1. In making experiments on the magnets, to determine the highest economical number of ampere turns, the connections were made as shown in figure 2. The current was furnished by a Gramme dynamo, A, which has its magnets magnetized by a small Weston, B. A Siemens & Halske electro-dynamometer was used to measure the larger currents, and a Thompson ammeter for the smaller ones. The galvanometer was a heavy astatic one. The ammeter was placed near the reversing key, and the galvanometer was on the farther side of the same room. The magnet was placed in a distant part of the laboratory, while the dynamos were still farther away. The narrow coil of fine wire placed close around the pole was in circuit with the galvanometer.

Now, a reversal of the magnet poles, by reversing the current through the magnet, causes a deflection of the galvanometer, since an induced current is generated in the narrow coil at the instant of reversing. The sine of the half-angle of deflection is proportional to the strength of the magnet. In my experiments the angle was small, and I have used the double deflections—*i. e.*, the difference of the right and left deflections as read from scale.

The induced circuit was always broken except at time of reversals and till the galvanometer reading was taken. This prevented, to a great extent, any disturbance of the galvanometer by fluctuations of current from the dynamo. It was convenient to place the key for closing the induced circuit upon the table that supported the telescope and scale for reading the galvanometer; hence a peculiar form of key was made that could be closed by pulling a cord, while standing at the other side of the room near the reversing key and ammeter.

Let us suppose the dynamos running, and the ammeter

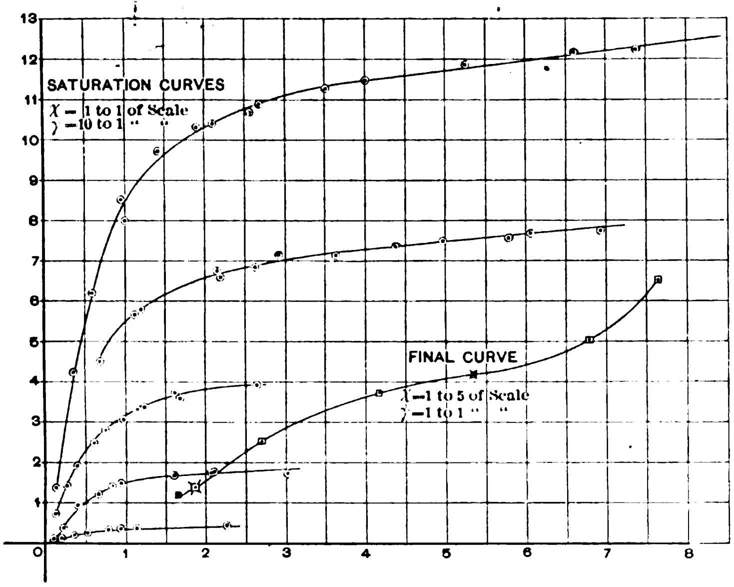

FIG. 5.

indicating a steady current; also the galvanometer at rest. I stand by the reversing key, note the reading of the ammeter, close the induced circuit (by means of the cord), reverse the current, and step quickly across the room to read the first swing of the galvanometer.

Four such reversals were made with each current, and the mean of the two double deflections used. Thus we have strength of current, and a number proportional to strength of magnet. The saturation curves for the different magnets are shown in figure 5.

To determine what the highest economical current is for a magnet, I drew a line coinciding with the rapid rise of the saturation curve, and another with the nearly horizontal part of it, and produced them till they intersected. Then bisected the angle thus formed. This bisecting line cuts the curve at a point midway between greatest economy and gre test waste of current. This method gives similar points in each curve. Ordinates of points thus determined are given below, opposite their corresponding diameter of core.

Current.	Diameter core.
.35 am.	1.22 cm.
.55	2.52
.83	3.76
1.37	5.08
1.52	6.34

Plotting currents as abscissæ, and diameters as ordinates, we have the "final curve," also shown in figure 5. The equation of this curve is $y = 8.8868\,x^4 - 25.80116\,x^3 + 22.07239\,x^2 - .93553\,x - .22125$; but the following simpler equation give close results, when values of x from the above table are substituted. $y = 9\,x^4 - 26\,x^3 + 22\,x^2 - .7\,x - .22$.

If we substitute for x .83 (see table) we have 3.76 cm. for the diameter of core which would be brought up to greatest economical strength by .83 x 1570 ampere turns. Again, if we substitute a value for y and solve for x we must multiply the value of x by 1570 (the number of turns on spools) to get the ampere turns.

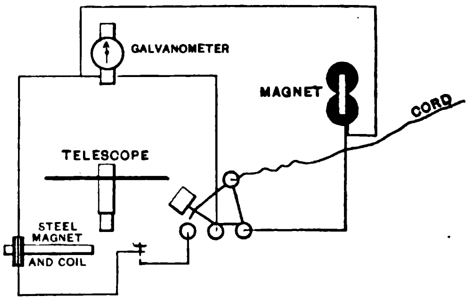

Fig. 3

Figure 3 shows more fully the connections with galvanometer at time of reversal. Figure 4 is a larger view of key for closing induced circuit.

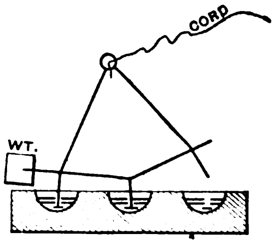

Fig. 4

When the experiment was begun, I intended also to use for the smallest two cores a set of smaller spools of No. 14 wire, with same number of turns as the larger, to see if a different "highest economical current" would be obtained. Also to make tests of magnets with one armature off, and also to test a magnet with differently prepared surfaces of contact between armature and core. These experiments were omitted for want of time. It will be seen that the method of reversals is that of Prof. Rowland.

THE SCHLESINGER SYSTEM OF ELECTRIC TRANSMISSION.[1]

BY W. M. SCHLESINGER,

Of Bradford, England.

ALTHOUGH but a short time has elapsed since the first successful practical application of electricity as motive power for railroads, nevertheless the number of electric

1. A paper read at the Stated Meeting of the Franklin Institu e, held Wednesday, October 20, 1886.

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roads now in operation is a comparatively large one. Not counting the roads built in mines, or small ones running on piers, there are at the present time about ten operated in Europe, and the same number in America. Of these, about half the number run only one car, while the others run from two to ten.

The gain of much practical experience is the natural outcome of the operation of these roads, and it is not to be wondered at, therefore, that a great many improvements have been made since Siemens ran his first train in Berlin, in 1879.

Electric railroads may be divided into two large classes. To the first belong all those that derive their current direct from the generators by means of conductors, with which they stand in constant communication, and to the second belong all those operated by means of batteries, primary or secondary. As the road to which I wish to call your attention belongs to the first class, I will only mention of the second class that primary batteries are no longer used for the propulsion of cars, whereas secondary batteries have been employed with success.

The requirements of a road of the first class are generators, motors, stationary conductors along the route, and movable conductors connecting these with the motors.

According to the position of the stationary conductors, the systems of the first class are subdivided into three classes. To the first belong all those that have the conductors on the surface. An insulated central rail generally forms the lead. The uninsulated rails on which the car runs are the return conductors. In some cases, as in Ireland, on the Portrush road, the central rail is dispensed with, the current being transmitted to the motor by the rails on which the car runs. In this case, the wheels of the car have, of course, to be insulated from each other.

The advantages of these roads are their great simplicity and strong mechanical construction ; their defects are that, owing to their unprotected conductors, they are dangerous to persons or animals crossing the track, and therefore better adapted to suburban roads. For the same reason the E. M. F. used with these roads ought not to be larger than 150 volts.

Part of these defects are remedied in the systems of the second class, which comprises all roads carrying the conductors overhead on poles. As it is impossible with these for persons to come in contact with both conductors at the same time, higher E. M. F. can be used, and every one acquainted with the theory of electric power transmission knows of what importance it is for the efficiency as well as economy of the plant to use the highest possible E. M. F. The defects of these systems are that they are mechanically not as strong as those of the first class, and that the poles required for them form an obstruction in the streets. Roads of this kind, although they may be suffered in smaller towns having broad streets, would be too great an obstruction to be introduced in the crowded thoroughfares of larger cities.

To the third class belong those roads having the conductors underground in a conduit, access to them being had by means of a slot in the latter. Roads belonging to this class have only recently been built, and but two are in operation at the present moment. These systems combine the advantage of those of the first class, in having ample mechanical strength, with that of the second in being able to use high E. M. F., and in addition to these, they do not form an obstruction to traffic in any way.

Of the two roads belonging to this class, one is located in England and the other here in Philadelphia. This latter road was not built for the purpose of making it permanent or profitable, but simply to demonstrate to the public the practicability of the system. By kind permission of President E. B. Edwards, of the Ridge Avenue Passenger Railway Co., we were allowed to use the track of that company, between their depot and South Laurel Hill, a distance of 2,600 feet, and having a three and one-half per cent. grade near the end at Laurel Hill.

Before giving a description of this road, I will try to show what is necessary to make a road of this kind successful. The great secret of success in electrical plants of all kinds is, as you all know, good insulation and simplicity of construction. With surface and overhead conductors, good insulation is comparatively easily gained ; not so with underground conductors. The slot leading to the conduit gives access not only to the collectors, but also to water, dirt and snow. The first requirement of the conduit, therefore, is to prevent these from coming into contact with the insulation, the second is to allow an easy and quick removal of these foreign substances.

In our present conduit we have tried to attain above requirements by building it in the following manner :

The conduit is 9 inches deep by $3\frac{1}{2}$ inches wide, its bottom is formed of a wooden plate $1 \times 3\frac{1}{2}$ inches, and against this the sides of the conduit are pressed and at the same time secured to the cross-ties by spikes. The main sides are wooden beams 4×7 inches and 15 feet long, and to this an iron rail forming the top of the conduit is secured by a number of bolts. This construction is, of course, not practical for permanent roads. These we have decided to build of strong channel iron nine inches high and from 15 to 20 feet long. Angle iron is riveted to the top flange in the manner shown in the accompanying figure 1. In this it will be seen that one of its flanges pointing downward parallel to the main side of the channel iron, forms one side of the slot. In the inverted troughs, formed in this manner, the conductors are fastened so that the contact side (*i. e.*, on which the contact pieces rub), is the lower side. The conductors are much narrower than the troughs, so that contact with the sides is impossible. Any dirt or water entering through the slot will therefore fall to the bottom of the conduit without interfering with the insulation. The conductors are made of copper bars, to the lower side of which channel iron is fastened. The object of the latter is to protect the copper from being worn away by the rubbing contact pieces of the collectors and at the same time to keep these latter in their places. The conductors are at each end of the section shorter than the latter and are there replaced by wooden mouldings, the object of which is to protect the insulation from water or dirt getting in between two following sections. These wooden mouldings fill up the whole space, between channel iron and angle iron and come within one-half inch of the conductors. The copper of one section is connected to that of

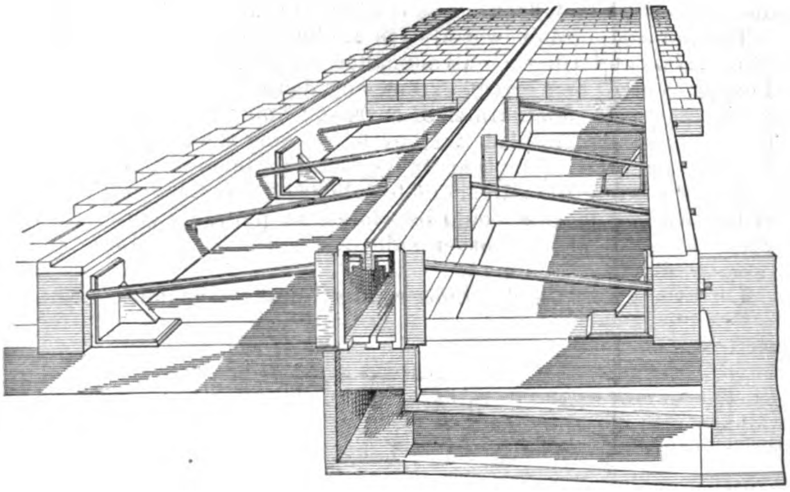

FIGURE 1.—Section showing Road-bed and Conduit.

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the following on our road on Ridge avenue, by means of well insulated cable soldered to the copper, and passing through holes to the outside of the conduit where the connection between the cable ends is made. After being well insulated this connection is placed in a recess cut in the wooden beam. This recess is then covered with a plank and filled up with pitch. For the sake of convenience when testing, these connections are at certain intervals surrounded by large, wooden boxes, with removable lids instead of being placed in the recesses. Figure 2, shows the connection between two following sections of our new conduit. Instead of insulated cables, the connection is made with pieces of copper, protected by an iron box the

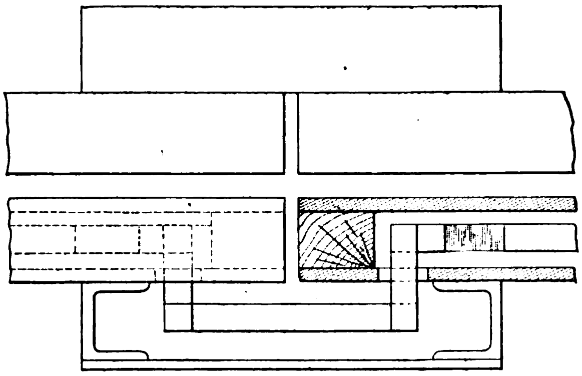

FIGURE 2.—Plan showing the Connection between two following Sections.

lid of which is removable. The object of making the connections in such a manner is to allow any section to be tested or cut out of the circuit, by taking the current around it through an insulated cable, without interfering with the conduit or the working of the road. Then again, as all sections are to be made of exactly the same size, it is possible to replace a faulty one in a short time by a new one.

To allow the removal or exchange of the collectors, or the inserting of brushes for cleaning purposes, openings are provided for at proper distances. These are covered by strong cast-iron plates, carrying in place of conductors wooden moulding. The current is taken around these traps, on the outside of the conduit, by means of insulated cable. This is done for the purpose of avoiding an interruption of traffic by the opening of these traps, and to prevent the conductors from being damaged through careless handling.

As above description shows, all appliances are secured to the top of the conduit, leaving a perfectly free space below, nearly seven inches deep. A device for cleaning the conduit can therefore be passed along the bottom, without interfering with the conductors, and the dirt that has fallen through the slot can be swept into pits, from where it is removed by hand. These pits are connected with the sewers to allow the rain water to pass off. Braces at the sides of the sections keep the slot at the proper size.

The insulation used is red fibre, well soaked in paraffine. Both lead and return conductors are perfectly insulated, as the slight advantage in cost, gained when using the rails as return conductor, is more than balanced by the greater security from stoppages, caused by faults in the insulation.

The insulation resistance of each conductor was about 12,000 ohms for 500 feet, while laying the road. This would have given 2,300 ohms for each side, the length of the road being 2,600 feet. On the 29th September, one side showed about 800 ohms. The fall of insulation resistance is due principally to the fact that the first 500 feet, which have been in the ground now for three-quarters of a year, were not built with the same care as the rest; then again, the distance between the conductors and side of the conduit was made too small, being only one-eighth inch. Another reason is, that owing to the comparatively few hours we are running every day, it was impossible to keep caterpillars out of the conduit. These crept up between the conductors and the sides of the conduit and cocooned there. Nevertheless, the resistance between conductors is so large that, with the E. M. F. we are using of about 160 volts, the ammeter does not indicate the slightest leakage. The insulation resistance between conductors is about 880 ohms, and the E. M. F. being 160 volts, the loss through leakage in the conduit is two-elevenths amperes, or 29 watts, or about one-twenty-fifth h. p. On the 4th September, the whole conduit had been submerged from end to end by means of four fire-plugs, situated along the road. On starting up, the loss was nearly eight amperes, but after the first trip, this was reduced to about three amperes, and, after two hours run, the leaking had stopped entirely. After a very heavy rain, the loss on starting up generally amounts to from one to two amperes, but stops after the first trip.

The main features of the conduit can be summed up as follows: Perfect protection of insulation against dirt or water coming in through the slot, or the spaces between the sections; facilities for cleaning it out; easy access to the connections for the purpose of testing or cutting out a faulty section; facilities for exchanging the latter for a new one, without interfering with the working of the road; easy access to the interior by means of the traps, and perfect drainage.

Perhaps the most difficult part of the whole problem was to devise a good collector, mechanically as well as electrically satisfactory. To give at all times good contact, this latter had to be made independent of the oscillations of the car, and at the same time fastened strong enough to it to enable it to overcome any obstruction in the shape of stones or wedges placed in the slot. The first collector tried rested on four wheels, and was pulled along by the car by means of strong chains. But although this fully accomplished all the electrical requirements, yet it had to be abandoned for practical mechanical reasons.

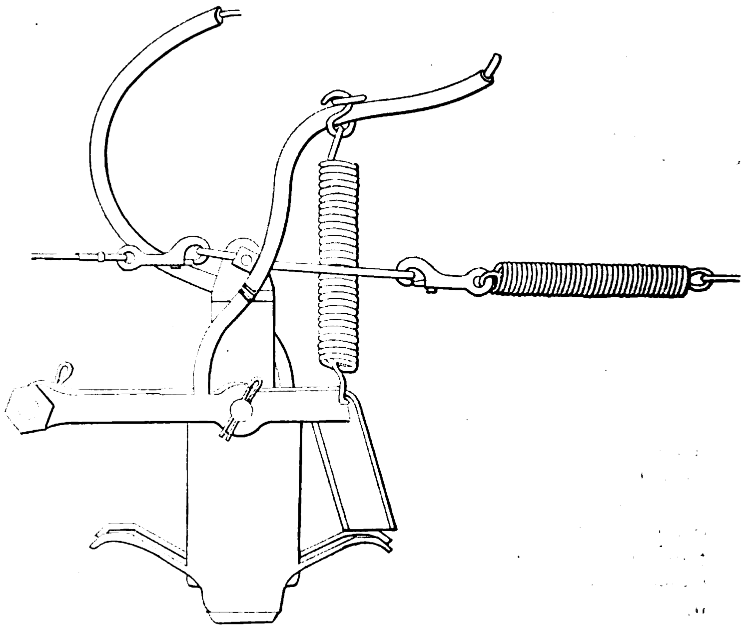

FIGURE 3.—The Collector.

Instead of this, the collector now in use was devised, and this combines good mechanical, with excellent electrical qualities. It consists, as figure 3 shows, of a cast-iron frame carrying a strong finger reaching into the slot to remove all obstructions. This frame is secured by means

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of a bolt to the car, in such a manner as to allow it perfectly free motion in a vertical, and sufficient in a horizontal plane. Through a fork in this frame a phosphor-bronze casting passes, fastened to it by means of a bolt, so as to swing freely in a vertical plane and to have enough side-play. This casting passes into the slot, and carries two steel springs well insulated from it and from each other. A strong spiral spring, which takes up all the irregularities in the motion of the car, presses the springs against the conductors. To furthermore insure good contact, the phosphor-bronze casting is connected by springs and wire ropes to a lever on the front platform. With this lever, the casting is tilted in such a manner that in going forward the front parts of the contact springs, and in going backward the back parts, are moved away from the conductors. Two such collectors are supplied to each car, one having the cast-iron finger pointing forwards, the other backwards. The contact between springs and conductors is perfect, as the incandescent lamps in the car and the ammeter at the station show. The connection between the contact springs and the motor on the car is made by means of well-insulated wires, protected where they pass through the slot by steel plates riveted to the phosphor-bronze frame.

Among the advantages that can be claimed for the electric motor over any other motor, small size and weight undoubtedly take a prominent place. Owing to these two properties, it was possible for us to place the motor on the car itself that is intended to carry the passengers, thus doing away with the cost, as well as extra power, required by a separate locomotive car. The motor on our car on the Ridge avenue is fastened to it below the body of the car, between the two axles, and, therefore, does not diminish the seating capacity in the least. The middle of the car was thought to be preferable to any other place, not only because its frame is strongest there, but also because the weight of the motor is equally distributed on both axles. The power is transmitted from the armature shaft to the wheels by chain-gearing. Unless the grades of the road are very steep, it is sufficient to connect one axle only with the motor; with steep grades and heavy loads, it is preferable to transmit the power to both axles, as then the entire weight of the car is effective for tractive power.

To allow easy access to, and good supervision of, the brushes of the electromotor, the commutator has been placed outside the bearings, the connecting wires passing through the hollow shaft. The motor in use on our car weighs 1,850 pounds, is built of cast-iron, and can furnish 13 h. p. By using the best possible material, like wrought-iron, for the magnets, both weight and size can be very much reduced. The motor designed especially for the purpose weighs about 1,350 pounds, takes up less room, and can furnish 17 h. p., or enough power to haul two cars on not too heavy grades. To protect the motor from dirt, dust and water, it is surrounded by a wooden box, having doors at the side, through which the commutator on the one side, the transmission on the other, can be inspected.

The speed regulation of the car was at first effected by regulating the strength of the field. It is a well-known fact that the work done by a motor within a given time is

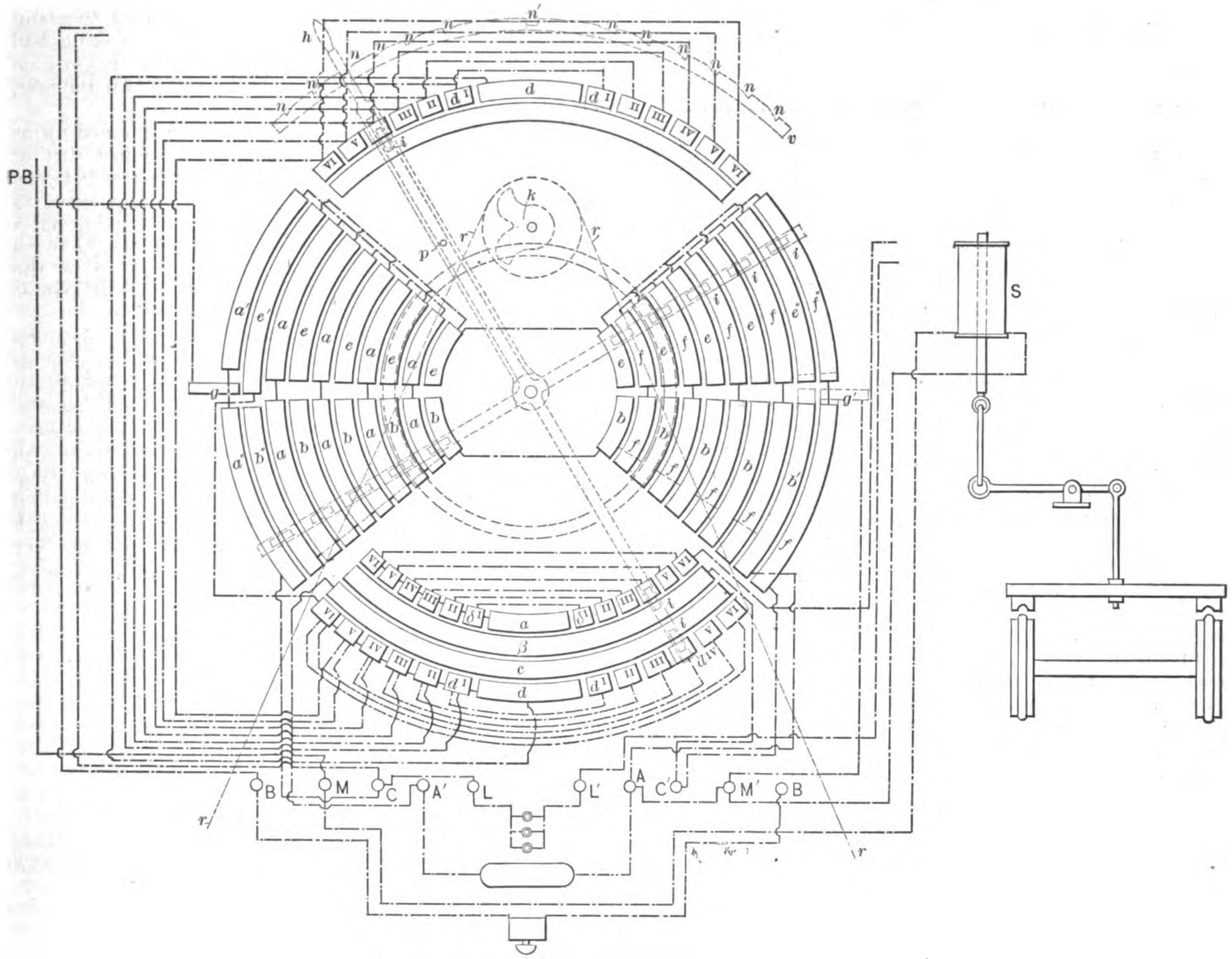

Fig. 4

at its maximum if the counter E. M. F. is half the E. M. F. and sinks, the nearer the former gets to the latter. On the other hand, the torque is greater the stronger the field, and as the load with which a motor can start up is dependent on this, it is essential to start up with the strongest possible field. When in motion, the required speed is attained by weakening the field, and thus the counter E. M. F. Our motor being a shunt machine, it was, of course, necessary to let the main current take several turns round the field-magnets, as, on closing the armature circuit, the low resistance of the latter before revolving would, of course, short-circuit the field circuit. As far as the motor was concerned, this regulation was very satisfactory, but, owing to the fact that one car only was being operated, it was found that the strain on starting was too great for both generator and steam engine. The regulation was, therefore, changed to one by means of wire resistance placed under the seats in the car. To allow quick and easy starting up, the field-magnet circuit is always in connection with the conductors in the conduit.

On leaving the conduit through the collectors, the current is taken directly to a regulator box on the front platform of the car, and in this the connections for the different circuits are made. To allow the cars to be run by unskilled men, like ordinary drivers, the regulation is so arranged that one lever only is required to operate the car. This lever not only allows the car to be started up either forward or backward, but also controls the speed of the same, regulates the light circuit, and controls the electric brake. A diagram, showing the connections in the box, is shown in figure 4.

The electric brake is composed simply of a large solenoid, attached to the car in a horizontal position. The core is made partly of brass and partly of iron, and, resting on brass rollers, has a motion of nearly eight inches. It connects, by means of a chain, with the brake-lever, ordinarily worked by the hand-brake. By putting in or taking out resistance in the solenoid circuit, the pressure exerted by it can be regulated at will. The feature of the brake is, that it can only be applied when the connections between armature and conduit are interrupted. It is thus impossible to endanger the motor by starting up with the brakes on, or by applying the latter while the motor is propelling the car.

In practice, it will invariably be found that, no matter how good the motor, or what automatic regulation is employed, the practical neutral line will shift from one side to the other of the theoretical neutral line on reversing the motion of the armature. To gain the best results and prevent sparking, it is, therefore, necessary to provide for means by which the brushes can be shifted to follow the neutral line. To effect this, we have connected the brush-holder, by means of wire ropes, to a fork, operated by the lever on the front platform. On moving the lever to either side, the fork is moved a certain distance, thus setting the brushes to one or the other side of the theoretical neutral line. When properly adjusted, the motor runs without a spark at the commutator; the brushes are trimmed every three or four days, the wear they show being mostly due to friction.

To supply the required current, a dynamo is used which is the exact counterpart of the motor. The armature is of the drum type, and the winding a modification of the Hefner-Alteneck winding. Owing to the fact that the current taken from the generator is very variable, especially when running one car only, it is impossible to use a series dynamo. On the other hand, it is rather expensive to make a shunt dynamo, giving as high an E. M. F. as 500 or 600 volts. Owing to this, and other considerations, we use separately excited field magnets in our generators, and have carried this out on Ridge avenue, although we there only use an E. M. F. of 160 volts. The exciter used is a small Hochhausen dynamo.

As to the efficiency of the road, it is impossible to give any exact data. The average speed of the car is a little above nine miles per hour; the weight of the car alone is about 5,000 pounds, the weight of the motor and other appliances is 2,100 pounds, giving the total weight of the empty car as 7,100 pounds, or nearly three and one-quarter tons. The capacity of the car is 45 passengers, which, at 140 pounds per passenger, give an additional weight of 6,300 pounds, a total weight of 13,400 pounds, or about six tons. The current required on the level is between 15 and 17 amperes, the E. M. F. being about 160 volts; on the curve on the grade about 45 amperes are required, the E. M. F. being only 135 volts, owing to the slowing-up of the steam engine.

[Since this was written, the connections of the first 500 feet of the conduit have been renewed, and, when testing on the 18th of this month, the insulation resistance of the one conductor was found to be between 1,500 and 2,000 ohms.]

DISCUSSION.

Mr. ———"How is it proposed to run more than one car?"

Mr. Schlesinger—By using a constant E. M. F., and placing the cars in multiple arc. The resistance of the motor is due to the resistance of its wire, and to the counter E. M. F. Of these, the first is a constant, but the second varies according to the speed of the car. Supposing the motor to have no regulation, its resistance will increase when the speed increases, and decrease when the latter decreases. The result is that, with a higher speed, the current passing through the motor decreases, and, according to the laws governing electric power transmission, the work performed decreases also. Should the speed decrease, the current passing through the motor, and the work performed by the latter, will increase. This means that, with a given load, and a given E. M. F., the motor, if no regulation is used, can only acquire a certain speed, and only a certain amount of current will, therefore, be able to pass through it, no matter what amount is produced by the generator. It is, therefore, just as easy to run more than one car, as it is to burn more than one incandescent lamp on the same circuit."

Mr. Wm. Tilghman—"What is the cost, as compared with that of horses?"

Mr. Schlesinger—"By taking into account the cost of coal, attendance, maintenance of plant and the interest on capital, the power required per car per day will cost from $2.50 to $3. The power, when supplied by horses, costs about $6."

Mr. W. Curtis Taylor—"How does it compare with the cable roads?"

Mr. Schlesinger—The cost of the plant required for an electric road is about one-fourth of the cost of that required for a cable road, the efficiency of the power transmission is from two to three times larger, and the wear and tear by far smaller. It will cost much less, therefore, to operate an electric road than it will to operate a cable road."

Mr. W. Curtis Taylor—"What is the cost of construction per mile?"

Mr. Schlesinger—"To change a horse railroad into an electric road with underground conductors, will cost from $20,000 to $25,000 per mile. This includes all the necessary machines."

DYNAMIC ELECTRICITY.

BY CARL HERING.

(Continued from page 406.)

CHAPTER V.

ARMATURES.—(*Continued.*)

In winding a Gramme armature, the following are among the most important points to be observed. The available space for the wire should be utilized as completely as possible, and therefore should contain no wooden or

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non-magnetic lugs or partition pieces, and as little as possible of the frame work necessary to hold the armature to the shaft, and no more insulating material than is necessary. The length of the wire should be as small as possible for the required number of windings, and therefore should be wound as closely as possible. The wire should be so wound as not to be liable to slip, one turn over another, or to change position after completion, as this loosens the winding, thereby causing abrasion and a resulting short circuiting in the armature. The successive layers should therefore, preferably, when practicable, be wound, as shown in figure 12, rather than as shown in figure 13, for in the latter case they

Fig. 12

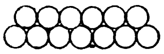
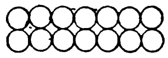


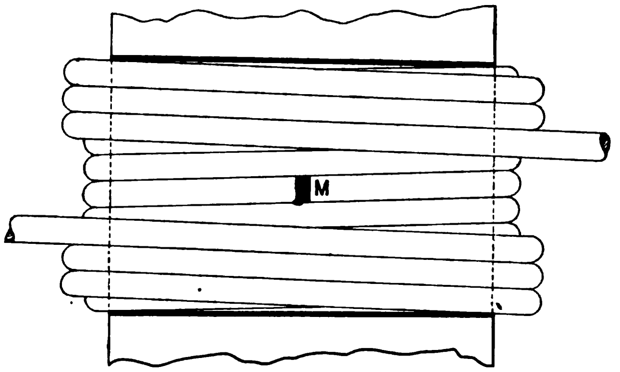
Fig. 13



may slip into the position in figure 12, thus loosening the wire and thereby decreasing the external diameter of the armature; although this may be very little, yet in many cases it might be just enough to loosen the tie bands around the outside of it, which may result in serious consequences. It is preferable, particularly in high potential machines, that the wires at the beginning and end of the same coil do not cross each other where they are tightly pressed together, unless carefully insulated, because where two single wires cross each other they touch in only one point, and it requires but a very slight amount of abrasion, or a slight blow, to crush the insulation and make contact, thus short circuiting that coil; and in many cases burning off the wires. Even if the insulation is not ruptured in such cases, a lightning discharge through the armature from an air line circuit, or a high self-induction spark, such as might occur when an accidental short circuit was suddenly broken, might "jump" through the insulation, thus starting an arc which the current of the machine would then maintain. An armature with few commutator bars and few coils of many turns is more liable to such an accident than one in which the windings per coil are few, and the electromotive force per coil correspondingly small.

In winding a Gramme armature in the ordinary way the wire from the beginning of the lowest layer has to pass to the outside between the coils, which in a well and closely wound armature will cause some irregularity in the winding owing to the space it occupies, particularly as it should have an extra insulation with tape. Furthermore, if this end breaks off short, as it is apt to do, the whole coil must be unwound. Both of these objections are overcome, while at the same time other advantages are gained by the following simple and ingenious winding which we believe is now largely used. Find the actual length of wire required for one coil, by winding it temporarily, cutting it to the right length, and then unwinding it. Cut the others to this length. Find the middle of the length of the wire for one coil, for instance by doubling it on itself, and mark this middle point. Start the winding by placing this middle point of the wire in the middle position of the first layer, as at M, figure 14, and having clamped or tied it, start with either end and continue winding just as if the middle point was the beginning of the coil, neglecting for the time the other half of the wire. The space for this first half of the coil when wound, must, however, be only half the width of the space for the whole completed coil. Having thus wound the first half, take the rest of the wire on the other half of the middle, and wind it in the same way in the remaining half space for that coil, thus bringing both ends of the wire, that is, both the beginning and end of the finished coil, on the outside layer. If there is an odd number of layers, these ends will be at the two ends of the outside or last layer, thus being in the best possible position to be connected to the end of the previous coil and the beginning of the next, respectively. As this brings both ends of each coil on the outside layer, it overcomes some of the difficulties in winding a smooth compact armature, and has the great advantage that there is no irregularity in the winding, nor is there danger of short circuiting caused by the beginning of the wire passing out between the others from the lowest layer to the outside. It also has the advantage that in case the end breaks off it is easily spliced as it can readily be unwound for one or two turns. In practice when there are more than three layers it is preferable to wind the half layers successively, and alternately with each end of the wire, as illustrated in figure 14,

Fig. 14



thus completing each full layer before starting the next. If the number of layers is even, the two ends of a completed coil will both be in the middle of the outside layer; this, however, is not objectionable.

When iron lugs are used between the coils, it is preferable to make them wedge-shaped so that the sides of the space for one coil are parallel, as this facilitates the winding and makes it smoother. If there are no such lugs the coil space itself is narrower inside the ring than outside and there will be more layers on the inside than on the outside; the winding will, therefore, not be quite as smooth at the curved ends but can be made to appear compact and smooth by placing a piece of cardboard under the last layer. Every dynamo builder takes pride in having handsome looking armatures, especially as a carelessly and loosely wound one carries with it the impression that the whole machine is built after the same fashion.

In order to make the winding smooth in cases in which no lugs are used, resort is often had to the device of placing strips of thick card board in the empty space in each layer on the outside of the ring, when the corresponding space onthe inside is full, in order to make them come out even. But in cases of armatures of small diameter and many layers, this wastes valuable space and had therefore better not be done.

Prior to winding a Gramme armature the spaces for the coils should be accurately and carefully marked off in pencil on the outside of the core after it is thoroughly insulated with several layers of shellaced paper or muslin. It is bad practice to wind the coils without spacing them off properly and to let the last coil take up any difference, for, as pointed out before, it is very necessary that all the coils should be alike in every respect.

When there are no iron lugs to serve as guides, it will be found greatly to facilitate the winding to make two wooden clamps as shown in figure 15, the oblong hole in the inside of which fits the core tightly, one side of each of the clamps being radial to the centre of the core. These are clamped securely to the core at the pencil marks of the space for a coil and serve to keep the coil in place while winding it. Two or three pieces of tape may be laid transversely in the troughs thus formed for the coil, and afterward closed over the outside of the coil when completed, thereby keeping it from collapsing when the wooden clamps are removed.

The end of one coil and the beginning of the next being fastened to the same commutator bar, the current in these coils has to pass through one of these, through the clamped

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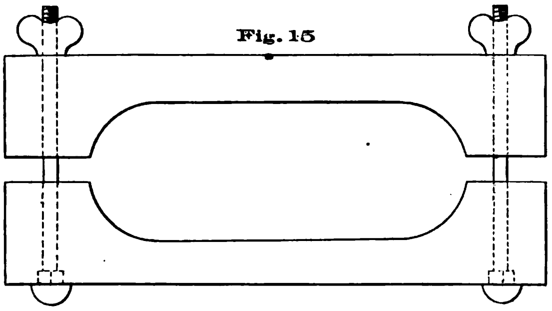
or soldered contact at the commutator bar, and back through the other wire in all of the connections except at the two or four where it flows off to the brushes. Although the resistance of each of these short lengths of wire, and of the soldered or clamped contacts, may be small, yet there are many of these resistances in series, and they may, therefore, form an appreciable part of a low resistance armature, especially when the contact with the commutator bars is not very good. It is therefore preferable to strip the insulation for a short distance on these two wires quite close to the coil, and either twist or bind them together and afterwards solder them. This is especially to be recommended in cases where the commutator is some distance from the armature, as for instance when it is outside of the bearing.

Fig. 15



Binding wires on the outside of the armature should be tightly wound and very well insulated from the wires, preferably with mica. It is better to make them narrow and at frequent intervals rather than broad and fewer of them, as currents are induced in them as well, and if broad, these currents have a chance to circulate through their very low resistance, thus heating them. If, as is usual, fine hard brass wire is used, all the wires of one band should be soldered together to avoid an uncoiling in case one of the wires is broken. Iron or steel tie wires should in no case be used as it would partially shield the core from magnetization.

Double covered wire only should be used for armatures. The windings should be shellaced, preferably with very thin shellac, while they are being wound. Armatures are frequently baked for a day to dry the shellac, especially when the winding is very open, as in spherical or carelessly wound armatures.

Iron wire has been suggested to replace the copper conductors, as it acts both as an iron core and as the conductor. But as the resistance is so much greater (about 6 times) it does not seem to have been a success in practice. Copper coated iron wire and copper wire covered with a thin layer of iron, have been suggested and we believe have been tried successfully.

The laminating of the core has already been described. It was shown that the best form was to make the core of thin discs separated by thin paper; but they are also frequently made of iron wire, which is first rusted to insulate it. The former is preferable, as the iron circuit of the lines of force in the core is then continuous, as distinguished from the course transversely to a bundle of round iron wires. In all cases the core as a whole should form a compact rigid mass; there should be no possibility of any parts of it becoming loose. Cast iron armature cores, even when cut with slits are bad. The iron is always much inferior to the soft wrought iron of plates or wires; it is often harder; it increases the length and resistance of the wire as it is necessary to have a larger bulk of iron to produce the same magnetic effect, especially as the cuts are necessarily quite thick; it is apt to break, and if made at all well it is probably but little cheaper than wrought iron. A notable illustration is in the Brush machine which formerly had a cast iron armature core which is replaced in the present machines by a wrought iron one, increasing the capacity of the machine, we are informed, from 40 to 60 arc lights, or 50 per cent. The wrought iron armature is said in this case to be no more expensive than the cast iron one.

It is best not to trust too much to friction to securing the armature to the shaft, but to fasten it by some more reliable method. A very small amount of slip may do a great amount of mischief. It must be remembered that the whole horse-power driving the dynamo, acts to push the wires of the armature over the core in a cylinder armature and to twist the core and windings off the shaft in a Gramme armature. The force to displace the wires is precisely the same in amount as if a brake band were gripped so tightly around the outside of the armature as to cause it to require the same force to turn the armature as when running in the field with its full load. When the armature is suddenly short circuited the sudden increase in this force to tear off the wires amounts almost to that of a blow from a hammer.

The core should have all edges rounded off smoothly, and should be thoroughly insulated with muslin, tape or paper, well shellaced.

The subject of the ventilation of armatures has, apparently, occupied much more attention among dynamo builders, than its importance seems to demand. The construction of armatures has been in many cases greatly complicated in order to convert the internal parts into fans and flues for ventilating; in one case the armature core itself was a sort of centrifugal blower sucking air in at the shaft and driving it out at the periphery. But to the technical engineer it cannot fail to be evident that it is much better to prevent the generation of heat in the armature by proper construction, than to sacrifice the efficiency by developing a large amount of heat and then still further reducing the efficiency by using part of the power to mechanically dissipate this heat by forcing air through the armature. There will of course be some heat generated in the wire and in the core; but by proper proportioning of the cross section of the wire, by proper lamination and insulation of the core, and by using soft wrought iron, this amount of heat may be made comparatively small; by increasing the diameter of the armature to present a large external surface, this heat can readily be dissipated at such a rate that the temperature of the armature remains low enough not to be objectionable. There is no objection, therefore, to making the core of the armature compact, without flues or vents, provided it is proportioned so as not to heat too much. Practice has shown that in armatures without internal ventilation the resistance of the wire may be so proportioned that it absorbs from 3 to 4 or even 5 per cent. of the total electrical energy.

Commutators should be made with as many bars as practicable for reasons mentioned before, as the number of coils is the same as the number of commutator bars. The absolute number of bars depends on numerous proportions of the armature, and must, therefore, be determined in each case. As a guide may be taken the results of good engineering practice, which show that in incandescent light machines of somewhat over 100 volts the number of commutator bars is so proportioned that the mean number of volts between two bars, that is, the induction in one coil, is from 4 to 7 volts. In other words, if the machine is to give 120 volts, and it is decided to assume about 5 volts per commutator bar, and if 80 per cent. of the wires are active, there will be $120 \div 5 = 24$ active bars on one-half, and as this is 80 per cent., the total number in one-half would be $24 \div .80 = 30$, making about 60 bars in all. In high potential arc light machines the number of volts per commutator bar must necessarily be taken greater as it would otherwise make the number of bars too great. The objection to a large number of volts per coil is not so great in arc light machines, as the current is always small in comparison to incandescent light machines, and the damage which a spark at the brushes causes decreases with the

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current. The long bright spark of a high tension and low current machine may not destroy the commutator nearly as quickly as the less bright spark of a machine giving a large current. Twenty volts is said to be the lowest potential that will maintain an arc; it is therefore preferable, if not almost essential, that the maximum volts per commutator bar should be less than 20, at least for those near the brushes, otherwise an arc between two bars may be established by the brushes which then continues to burn, causing the well-known flash encircling the whole commutator.

The thickness of the insulation between the bars should not be less than one fiftieth of an inch, as the danger of the "jumping" of the self-induction spark becomes too great if the distance is much less. In a case in which this was less the commutator was seen to be covered with myriads of small sparks, which, although doing little harm themselves, are too apt to establish more dangerous arcs. The material used for insulation should not be anything that will char, thereby being converted into conducting carbon; it should not be gritty as it then acts to wear off both the brush and the commutator; it should not wear off less rapidly than the bars, as it would cause the brushes to vibrate, causing sparking, and an objectionable humming noise. Air insulation between the bars is not good, except where the space can be made very large as in the Brush and Thomson-Houston machines, as it is too apt to fill with copper dust or other conducting material, making contact between them.

The connection of the coils to the commutator bars are either soldered or else clamped with screws. The objection to the former is, that the whole armature has to be returned to the makers to have the commutator renewed, while the objection to the latter is, that the screws do not make such a good contact, and are apt to become loose and open the circuit. The choice between them is the choice between two evils. If the wire terminals are in the form of flattened loops, and if the screws are frequently overhauled, the latter is probably the better method. Rosin should always be used as a flux in soldering, in preference to acid, except when used by skillful and careful persons, as a drop of acid on the coil or core may do considerable damage in course of time.

For single machines, a commutator is easily made by casting it as a massive cylinder, turning it off to fit the holder and then cutting it into strips on a gear cutting machine. These strips are then insulated and fastened together in the usual way with conically surfaced rings.

In order to bring the brushes, or the line of commutation into a convenient position, the connections to the commutator may be made at an angle, as if the commutator had been twisted at an angle with reference to the armature, after the connections were made. This is often resorted to as one of the "tricks of the trade," to make it appear as if the neutral line was exactly perpendicular to the axis of magnetization.

The brushes should not be made of wire alone, as they are too apt to cut grooves into the commutator, therefore necessitating frequent dressing of its surface. Nor should they be of solid sheets if they are broad, as they then do not always make good contact along the whole width. They should be cut lengthwise into narrow strips, and should, for large current machines, be quite thick. A good brush for incandescent machines, may be made with alternate layers of wire and sheets with longitudinal cuts in it. A brush should not at any time touch more than two bars, except when there are very many commutator bars, and when the distance between the pole piece projections, or the width of the neutral field, is very large. It is a mistake to think that when the brushes are pressed down very hard the sparking is diminished; on the contrary, this often increases the sparking. With well fitting brushes and a smooth commutator, it will suffice to have them touch very lightly only, provided they do not vibrate so as to leave the surface.

(To be continued.)

THE APPLICATION OF ELECTRICITY TO RAILROAD SIGNALING.[1]

BY GEORGE W. BLODGETT,

Member of the Boston Society of Civil Engineers.

The part of the evening's exercises which falls to me is a brief description of the electric apparatus for railroad signaling in use on the Boston and Albany railroad, followed by some general considerations on the use of electricity for this purpose. I begin with

LINE BLOCK SIGNALS WITH RAIL CIRCUITS.

The road is divided into sections of from one-fourth to one mile in length, according to the amount of traffic or local circumstances, each of which sections has a signal at the beginning, operated by clockwork and a weight, and which is set to danger whenever a train enters the section from any point, and restored to the position indicating safety when the train leaves the section. Each section is electrically insulated from those before and behind it. At the end farthest from the signal is an electric battery giving a constant current, which is connected to the track, one pole to each rail; at the signal end of the section the coils of a relay are connected to the rails in like manner, so that there is a constant flow of electricity from the battery through one line of rails to the relay, through its coils to the other line of rails, thence by these rails back to the battery. This relay controls the local circuit (so-called) of another battery through an electro-magnet in the signal, which governs the motion of the clockwork operating it. The successful operation of signals by a rail circuit requires that the *electromotive force* (or pressure, as it may be considered) of the battery connected to the rails shall be so small that there will be very slight leakage from the rails even in wet weather. It is found advisable, therefore, to include in a track circuit only the coils of a relay of low resistance, and make this relay open and close the circuit for another battery of any size we wish, which shall operate the signal itself. Both circuits are normally closed, that is, there is a constant flow of electricity through the whole length of each. The clockwork is so constructed that when the current is passing through the magnet, the signal is held in the position of "all clear," or "safety." When this is interrupted, the signal takes the "danger" position. When a train enters the section the current in the rails takes the path of least resistance, through the wheels of the train, instead of the relay magnet. The armature of this relay falls away from the magnet and opens the circuit of the battery controlling the signal, and this takes the position denoting danger as long as the section is occupied. When the last pair of wheels passes out of the section the circuits are again closed, and the signal shows clear. The same effect is produced whenever, for *any* cause, either circuit is interrupted—for instance, if the battery fails, or the wires are broken, or the clockwork is run down, the signal shows "danger" until the difficulty is removed. If a rail in the track is broken, and the parts separated by even so much as the $\frac{1}{100}$ of an inch, the signal will be at danger. I have known many instances of this, and not a few when the indication was most timely. One which happened on the road with which I am connected was a break where the parts were displaced by a space of an inch or two in such a way as to be almost certain to derail a train. The next train to pass would have been a "New York express"—a heavy train, running at a high rate of speed. The track was on an embankment, with a swamp each side. Before the train arrived the position of the signal had fortunately called the attention of the man in whose charge it was to the fact of some derangement, and a search was instituted, with the result named above. Another broken rail, first indicated by a signal, was discovered only after several days. This break extended upward and forward (in the direction

1. Read April 17th, 1886. From the Journal of the Association of Engineering Societies.

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of the traffic) from the bottom of the rail. The parts were so near each other as to leave only a small space—a hair's breadth—between them. In the daytime, when the sun shone, the expansion of the rail would force the parts together, good electrical connection would be made, and the apparatus would work perfectly; at night, on the contrary, the contraction of the rail would cause the parts to separate and interrupt the circuit and the signal would be at danger. A train would also sometimes slightly displace the parts so as to leave the signal at danger, when perhaps the next train would bring them together again. A pair of fish-plates bolted on was the remedy.

To make perfect electrical connection between the rails, a wire extends past each joint, the ends of which are connected to the two rails by a tight-fitting pin in a hole in the flange of the rail. While rails are new, and fish-plates tightly screwed up, this is not absolutely needed, but as soon as they begin to rust there is trouble if the wires be not attached to the rails. I have known signals work for several months with an unwired track, but ordinarily they will do so only a few weeks, even if rails and plates are perfectly new.

The moving of switches off the main track causes an interruption of the track circuit and sets the signal to danger; replacing the switch restores the signal.

Cars may be left on turnouts so near the main track as to endanger trains passing on that track. To prevent collisions from this cause, turnouts are connected with the main track by wires in such a way that if any part of a train stands dangerously near the main line, it will keep the signal at danger. Trainmen must, therefore, take care to push cars left on turnouts far enough from the switch to clear the signal, when they are sure to leave main line trains room to pass.

When the block signals are continuous—that is, with no spaces between the sections—the safety of trains following each other at short intervals is very greatly increased by *overlapping* the sections. This causes a signal to remain at danger until the train has passed a certain distance (usually about 1,000 feet) beyond the next signal. While a train is running this short distance there are *two* red signals behind it, one at the beginning of the section where the train is, and the other at the beginning of the preceding section. So long, therefore, as trains regard the indications of the signals, they can never approach each other nearer than the length of the overlap.

Signals are placed a short distance (about 200 feet) from the beginning of the section, in order that the engineer of an approaching train may see the signal operate for his train. Should it fail to do so, he is to proceed just as if no signal were there, and protect his train as circumstances may require. He is instructed to report at once such failures, in order that the cause may be removed without delay.

The engineer of every train stopped by a danger signal must report the stop and the cause, *if known* (as for instance, a previous train in section, an open switch, etc., etc.). If the cause be unknown to the engineer, he simply reports a stop from "cause unknown," and it is put in the hands of a repairman to investigate. When he has ascertained the cause (a broken rail, derangement of the apparatus, failure of batteries, or other cause not at first apparent) he returns the report with his explanation. If *he* cannot find out the cause, he also reports cause unknown, and we usually never ascertain. There is a small fraction of one per cent. of such stops at signals. Some of these I am morally certain are due to previous trains, open switches, or other legitimate causes; but in the absence of positive proof, do not feel authorized to classify it as such. Sometimes employés accidentally cause stops of trains at signals, and in order to save themselves the consequences, carefully conceal the fact, which is not always afterwards discovered, and when this is the case such stops have to be reported unknown.

Every month a strict debit and credit account is made up of the operations of the signals on each division of the road, which shows at a glance what proportion of stops are due to neglect of employés, defective apparatus, unavoidable causes, etc., as well as all legitimate stops. Employés are held to a strict account for all avoidable stops caused by them, and the number has been reduced to one surprisingly small. (In January, February and March, 1886, the ratio of these stops to number of operations was $\frac{1}{3766}$, $\frac{1}{5138}$, and $\frac{1}{11618}$ respectively, on the division where there are most signals.)

INTERLOCKING.

The applications of electricity to interlocking on the B. & A. R. R. are for the purpose of making sure that when a right of way has been given a train to pass through a section at speed, the track cannot in any way be changed until the train has passed entirely off the section. This is accomplished by applying electric locks to the first levers of all conflicting routes, but not to the signals of the route to be used. The locks are controlled by an ingenious form of relay (invented by Mr. C. A. Scott, of Boston), with two armatures at right angles. One of these is connected with the distant signal, of the route to be used, and the other with the locks of conflicting routes. For ordinary trains the distant signal is not given, and the locks cannot be applied, but if the distant signal is pulled clear, the apparatus is so arranged that when the train enters the section the locks will hold the levers of conflicting routes as long as the train is there. It thus requires the coincidence of two things to apply the locks—a clear distant signal, and a train in the section. This signal is only used for express trains and such others as are to run at full speed through the section.

I come now to the second part of my paper:

An engineer in considering the use of electricity for railroad signaling or in connection with interlocking, is brought face to face with the following practical questions:

1. Can we depend upon electricity to operate apparatus with certainty and regularity? What special precautions are necessary to secure this result?

2. To what extent are we justified in using it?

3. Does electric apparatus have the tendency to diminish the care and watchfulness employés would use without such adjuncts?

4. Should it be as far as possible *automatic?*

The answer to the first question to some extent covers that to the second. Electric apparatus is certainly open to some sources of derangement, which mechanical appliances are free from. Some of these are exhaustion of material in the batteries employed, breaking of the circuits due to (*a*) a broken wire, (*b*) a broken jar in the battery, (*c*) corroded or rusted connections (which, while they are not actually divided, prevent passage of the current); freezing in winter, evaporation in summer, neglect of proper care, breakage or wearing out of delicate parts of the apparatus, fixed magnetism in iron or steel parts, and some others.

In order, therefore, that we may depend upon electrical apparatus with at least as great safety as upon mechanical appliances, we must adopt such additional precautions as shall meet these particular liabilities to derangement. For this purpose, each application must be looked upon as a special case and be considered by itself. Electricity must be made to watch for its own failures; sometimes this must be done to the extent of using secondary apparatus, the only purpose of which is to show when the principal appliances are out of order. This means in most cases a closed circuit and a constant consumption of material; we do not yet know how to make a circuit, normally open at one point, show an accidental interruption at another point In many kinds of apparatus the constant circulation of current to the extent necessary for this can be maintained by a small amount of battery, since a very

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much smaller current will suffice to hold apparatus in position than would be necessary for its operation. Expense of maintenance may thus be diminished.

The normal position of railroad signals should be danger; the electric current should be made to do something positive in order to indicate safety. A signal showing all clear should require that the track to which it belongs is continuous and unoccupied by any portion of a train, the switches all set for that line and locked there, the conflicting routes (if any) locked at danger, and that the electric apparatus is in good order *and actually at work.*[2]

If electricity is applied to lock levers of mechanical apparatus (in my judgment one of its most important uses), a lever unlocked should mean that the route it governs is safe for a train to pass, all conflicting routes shut off, and the electric apparatus working in good order.

The principal consideration ought to be, not how cheap apparatus can we get, but how reliable can we make it. Often it is a question of durability alone that needs to be answered. I know of but few railroads or other corporations which adopt strictly this principle of good apparatus at any price, rather than poor and unreliable appliances because they cost little. I have known repeated instances of a first-class corporation buying cheap electric apparatus because of a less first cost, which was soon more than balanced by large expenses for repairs (sometimes to the extent of replacing the whole apparatus with better), to say nothing of its unreliability. In a few cases I have known it to actually pay more money for poor apparatus than better materials and work would have cost at the start. In no class of work is the old proverb, "well done is twice done," more true than in electrical instruments, but there are few who believe it. It is this short-sighted and contemptible policy of attempting to save a little money by the sacrifice of safety and reliability, that stands in the way of progress and perfection of electric apparatus; there is no inducement except the self-respect of him who does the work, for making the *best thing* in the best way. There are a few who will do what they undertake thoroughly or not at all, but though they may have many times demonstrated the different quality of their work, and its lasting character, their life is often a struggle for existence, while competitors who have thrown conscience overboard and principle to the winds, thrive in business and grow rich, for no reason except that they can place their wares in the market at a lower first cost.

Used in the way I have indicated, with proper safeguards, mixed (as an artist once said of his colors) "with brains," electricity is one of the safest and surest of agents, and its occasional derangements need never cause an accident or serious inconvenience.

The second question, "To what extent are we justified in using electricity for railroad signaling?" may be answered by saying that it is largely a question of expense. We know of no way of obtaining small quantities of electricity for constant use in all places so conveniently as from batteries. The maintenance of these is expensive, both for labor and material. If we wish the current to do any considerable amount of work, we must have a large number of these. The expense involved in their care may then be a complete bar to the use of electricity for a proposed purpose.[3] We shall ordinarily find the best solution of the problem in hand by working heavy pieces of apparatus by mechanical means or man-power, and *controlling* the movements of the operator by electricity.

In the case of interlocking, for example, let the switches and signals (for the most part) be moved by some mechanical means, and let electricity limit the signalman's movements to such as are at the moment perfectly safe and proper.

When a train has accepted a right of way which has been offered, its very presence there should make it impossible for a signalman or anybody else to change the route, or to interfere in any way with the safe passage of the train until the last pair of wheels has rolled off the section. It should, however, always be in the power of a signalman to put a signal at any time to danger and stop a train. It may happen that when a train which has been given a right of way has begun, or even nearly completed, its passage, it is imperative to recall the right of way and hold the train from completing the movement, until such time as the emergency which made this necessary has disappeared. No electric or other device should, therefore, ever be applied to interlocking or mechanical block signals, to lock a signal in an all-clear position, but the locks should apply to the first movements of all conflicting routes, and remain so applied, whatever be the position of signals belonging to the route occupied, so long as such occupation continues. This is, I think, the great field for the legitimate use of electricity in connection with railroad signals, viz., as a controller or governor, to secure the legitimate and safe use of other forces directly working the apparatus. For this purpose, it ought to be applied wherever it can help to secure (or to indicate) an unbroken or unoccupied track until the train using it has completed its passage in safety.

Third.—"Does its use have the tendency to diminish the care and watchfulness employés would use without such adjuncts?" I think not; it ought rather to teach signalmen safe and careful use of their apparatus, since they can normally make no other; for trainmen it ought to teach prompt and fearless occupation of routes prepared for them, in confidence that they cannot be taken away so as to cause disaster. With some employés it may possibly be true that the more precautions which are taken for the safety of life and limb, the more reckless they become, but such men have no legitimate business with the operation of a railroad; for the others, without regard to the laws upon the subject, is it not the duty of every man or corporation employing men in positions of danger to use every possible precaution, within the bounds of reason, for their protection, and to counteract any tendency to too great reliance on devices of this kind by securing better discipline, a more conscientious performance of duty, and better appreciation of the dangers of their business?

Fourth.—Ought it to be as far as possible *automatic*, or like a tool in the hands of some employé? It is a sufficient answer to this question to say that experience has always shown that whenever the forces of nature or mechanical principles can be substituted for human perception or judgment, there is a great gain in certainty and safety. Electric signaling apparatus should, therefore, be as far as possible automatic. The information conveyed by it must be instantly and perfectly intelligible from the first moment when its indication can be of service. If a *visible* signal (as is usually the case), it must be in form, position and size such that it may be seen a long distance.

In location and color, the signal and the background against which it is seen must be such as never to be confounded with something else in the same vicinity. To secure this, it is often necessary to make a special background for the signal to be seen against, or to place it differently from what would be done on general principles. The proper location and details of arrangement must be determined for each separate case.

"A signal displayed at or near the point of danger (say the Mass. Railroad Commissioners, in their report for 1879)

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2. An ideal system of signals ought to provide that a clear signal shall insure to a train about to pass through a section at speed that all the switches are set for the main line, and the presence of the train in the section should automatically lock every switch till the whole of it has passed out. Attempts have been made to do this, but so far as I know they all failed. I think the failure due to imperfect apparatus rather than faults in the principle, and I see no reason why a system cannot be devised whereby all switches shall be automatically locked by the entrance of a train into a section and unlocked by its passage out. Of course for a train intending to use any switch, there must be means for unlocking that particular switch for that particular train.

3. There may be an apparent contradiction between this statement and the principle laid down in the preceding paragraph, but it is only apparent. Here the question is, shall we use electricity or some other agent for the work we have to do? there the question was, what kind of electric apparatus shall we adopt? The first must be decided by consideration of each particular case as it arises. We can answer the second once for all.

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is utterly insufficient and unsatisfactory." It should, then, be far enough from the point of danger to allow stopping any train, in any weather or state of the track, before reaching that point. If that be on a curve, the signal should usually be placed far enough back to be seen from a straight line. If the curve is so long that this cannot well be done, an allowance must be made in distance; a similar allowance should be made where a signal stands on an up or down grade, but it should not be placed so far away as to make it likely that any interference with the track can be made after a train has passed the signal at speed and before it reaches the danger point.

Electric apparatus should of itself warn and protect from danger, and not be merely an instrument in the hands of an employé by which he can notify his fellows of danger he has discovered some other way.

Electricity, intelligently used, makes the eyes and hands of its master indefinitely extended, and to those who know how to apply it, is as certain to do its work as steam or water, and, unlike these, can be made to give warning, not only of its own failures, but of those of the hand that uses it.

NOTES ON THE APPLICATION OF RAILWAY SIGNALS.[1]

BY G. R. HARDY,

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AUTOMATIC signals are used to show to the engineman of an approaching train the conditions of safety or obstruction which may exist in the section of track beyond the signal. Their value usually relates directly to main-road trains and the certainty of a clear way for such a train.

With the station block system, the automatic signal provides protection which is modified by the length of the section and locations of the parts. Such applications of isolated sections almost invariably include some switches. This condition of isolation subjects a train which is only just drawn inside the signal, which ought then to become a protection to the train, to a danger from a following train which is warned by a signal only immediately in the rear of the first train, while not enough room remains for the second train to avoid a collision. In the hope of avoiding this element of danger, there appears a tendency to locate the signals more remotely in the rear of the usual stopping places of trains, such a distance as would provide a generous protection and warning for the first train against the following train.

A second element appears now, which should modify such a disposition. In order to have the signal faithfully express an unobstructed track it is necessary to so connect the switches that when one is thrown off the signal will warn a train. When the signal shows all clear the train should advance promptly, but unless electric locking is provided it still remains possible to reverse the position of the switch after the train has passed the signal, and in case of a rapid advance, a safe stop may be impossible after coming in sight of this lately misplaced switch. Of course, if a train is in sight or its approach is announced, one would hardly undertake to shift the switch. Therefore, only a limited distance should be permitted between the signal and the most immediate switches. In practice, a distance of between 1,200 and 1,500 feet is considered best, or one quarter of a mile. When a train is stopped by a station block signal its rear is not protected automatically. This defect is better provided for by the application of the overlapping block system.

OVERLAPPING BLOCK SYSTEM.

This arrangement gives a signal which shows an unobstructed track after a train has not only cleared all the distance between the first and the second signals, but has gone a reasonable distance beyond the second signal. While occupying this last named distance or space of track beyond the second signal, both the first and second signals remain at danger; but after passing clear of that space the second signal will be at danger. This arrangement of signals is calculated to afford the largest degree of protection of any plan yet known.

The methods of establishing an accurate relation between track and signal are various, but some qualifications ought to have large prominence. A feature of automatic signals is a peculiar closeness to the immediate purpose of the signal; that is, the all-clear signal, if such a clear way is open, otherwise a danger signal for one of many reasons, but no further indications are presented. No agent or employé appears to explain the obtrusion. Only this is known: the signal shows danger and a stop must be made, and then, in the absence of information, the train may proceed with caution; caution here meaning only at such a speed as that the train may be brought to a stop clear of any obstruction which may appear on the track.

Automatic signals are commonly understood to include all kinds of signals which are operated by the presence of a train, and include many and various devices in the detail, such as clockwork and rougher mechanism or instruments, either kind of electric propulsion, pneumatic, hydraulic, or other means of actuation. In general, they may be classified under two kinds. 1. Those that are operated by the action of a train on a track instrument. 2. Those that are provided with a track or rail circuit. This latter class presents an advantage over the others in that one pair of wheels or one car, either detached or the last car in the train, as the case may be, if remaining in the section, continues by its presence there the same protection that was afforded by and for the whole train. Indeed, that method increases the working length of the section by a distance equal to the length of the train, and that too without the usual corresponding disadvantages of such an extension of length of section. Also in a case of a train parting in two the rear end of the train is protected as long as it continues in the section, even though the engine may have passed out to a point that would with the use or dependence on track instruments have released the danger signal behind its train. Lastly, a second train in a section is protected even though the first train may have passed out. The danger in both these cases, with the use of the track instrument system, is increased beyond that of the ordinary risk of operating a road without any signals at all, because the signal by its usual fidelity in warning the conditions of safety soon comes to be regarded as a guarantee of the clear road if it has been released and the danger signal reversed to safety. In respect to the fact of a second train in the section, the questions may arise as to what moment circumstances will discover two trains in a section at one time.

With automatic signals in this country it is considered entirely impracticable to despatch trains on the road, bound by the iron-clad rule of a positive block for automatic signals. Such a rule would result in frequent blockades and useless delays. Hence the modification by which the permissive block system is practiced, viz., stop for a danger signal and proceed only as the way is known to be clear. With a crowded service or irregular or delayed trains occasions result in a second train getting into a section before the first train has cleared the same section. Now, as the first train goes out, and if it is to reverse the protecting signal by running over a track instrument at the remote end of the section, it does so and removes all protection for the second train, and a third train is invited to proceed without any warning of the obstructing proximity of the second train. This is no imaginary combination, but has been seriously illustrated.

To briefly resume.—First, protect stations and stopping places with a station block system, one for each direction

1. Read April 17th, 1886. From the *Journal of the Association of Engineering Societies.*

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of the service, selecting first the locations most used by trains, and at higher speeds, and which afford the most limited range of vision for the engineman. By weighing these various elements, which in their accumulation serve to characterize the more dangerous localities, good judgment and experience will be able to designate those at which such appliances will afford the largest degree of insurance for the outlay. Hardly a full-grown railroad exists that may not, could such insurance be computed, save money enough in wreckage and repairs, and advantages to the service, to continue an increasing annual expenditure until its lines are well protected.

Second.—In completing the work thus begun, other independent points, such as isolated switches and junction points, and sharp curves and longer curves on steep grades will be commended to one's judgment as places for the station block applications ; and at the same time certain large stations, where the approaches are for a long distance characterized by the before mentioned elements of yard switches, blind curves, crossings and junctions, it will be seen to be advisable to advance the protection by dividing these approaches into sections, and entering the applications of the overlapping block system, which conforms readily to any already established system of station blocks; some minor changes and the additional signals are all that are required. In all this argument I am looking at the question as being confined to the track circuit system or its equivalent.

Most automatic signals are now arranged to stand normally all clear, and show red when there is danger in the way. This may be some time improved so as to stand normally at danger, showing red, and open to let an advancing train enter, which would be a more logical system, but its adoption is just now attended by some undesirable complications which hardly warrant such a change. One of the first track instrument systems used two signals, a second or tell-tale signal being about 1,000 feet beyond the first, at the entrance to a block, and by its mechanism standing at danger if the first was all clear, and changing to all clear after the first went to danger, which occurred as the train actuated a track instrument located opposite the first signal.

The form of signal is an important element, and simplicity should not be lost sight of. The common form of red disc or banner to indicate danger is quickly comprehended, and sufficiently conspicuous, as by common consent that color is so considered, and also its marked contrast with ordinary backgrounds is better than any other. Too large a variety of forms is undesirable, and perplexing to the engineman ; all should harmonize together and follow some definitely marked system. Depending solely upon color is questionable practice, and with the color-blind its consequences are fatal. Form or position assisted by color are now recognized as more acceptable. The logical sequence of natural signs and certain previous conditions leads up to the present features of consistent and not too complicated signaling. The natural use of the color red, for instance, accepted by all mankind and some lower animals as a danger signal, leads to its almost universal adoption in that capacity. As making the best contrast by day, the clear white is used for all clear ; but at night, a green light, complementing the red light, makes the safest running signal, and is less in danger of being confounded with the village lights, which might be presented in the range of view.

The form of a signal may be drawn from natural practice, that is, in order to stop a train vigorous motion across the track or nearly horizontal are quickly understood ; from such habits one regards a horizontal position as indicating stop and a vertical position or movement as meaning all clear. Retaining closely the horizontal and vertical features, as having distinct meanings, and we lead up to an appreciation of the semaphore with its horizontal stop and dropping to an all-clear or nearly vertical position. With this argument we should be inclined to use the semaphore for automatic signals ; but with automatic signals worked entirely by electricity, or by electricity and clockwork, it is found better to use the disc signals, on account of the difficulty of providing a sufficient actuating force to move the semaphores when the usual counter-balancing has been destroyed by accumulations of snow or ice, which difficulty exists in a very much less degree with disc signals rotating on a vertical axis or on a horizontal axis, when inclosed in a case with glass front protecting them entirely from the weather, although liable to be covered with snow in case of damp storms. When the track circuit system is reinforced by power from a pneumatic apparatus, then the force is considered sufficient to move the regular semaphore signals. Such applications have been extensively experimented with, and involve the running of a pipe to convey the compressed air, with machines at intervals of a number of miles to compress the air, also about the usual amount of wire, such as would be required for electric track circuit alone.

Another point in the use of semaphore signals automatically is this :

Most of the applications, so far, with automatic semaphores have been with that form of signal which, when united with interlocking, means a positive stop, and it would seem to be more consistent to avoid such a use of the absolute stop signal, either by the adoption of some distinct form of signal—not a semaphore—or by the use of the dove-tailed semaphore, such as is used for a distant signal.

No railroad can afford to despatch trains with positive orders not to pass a semaphore stop signal. If such a signal is provided to work automatically, and if the permissive block rule is granted for a form of signal which is automatic in one location while subject to all the uncertainties of electric appliances, and in another location is under the authoritative control of a signalman, it seems that the controlling value of the signal is exposed to strain. It might some time be claimed by an engineman, arrainged for ignoring the latter at an interlocking application, that he thought it was one of the automatics which the permissive block rule would allow him to pass. Indeed, there is but one difference in the rules relating to a danger automatic signal and a distant semaphore—namely, at the automatic signal for danger *stop* and proceed only as the way is known to be clear, while with the dove-tailed distant interlocking semaphore, the rule, when the signal is horizontal, is to proceed only as the way is known to be clear. It is not the purpose of this argument to claim that automatics should be dove-tailed semaphores rather than disc signals, but that if it is deemed necessary to use automatic semaphores, then by all means use the dove-tailed signal in preference to the positive stop semaphore signal.

There seem to be fair grounds for reasoning that automatic and interlocking signals occupy distinct fields of protection, and only overlap one another in their effects under certain circumstances. While interlocking is an old and tried institution, automatics are unique in their character. They are an American's attempt to accomplish cheaply what an Englishman does at large expense, namely, to so block the road as to keep irregular or delayed trains from accident. They are indeed a most valuable substitute, and obtain for the line using them almost the perfect safety which the English lines attain by sectioning the roads with men in towers provided with semaphore signals. While our lines are long, with less frequent stations and fewer connections with switches, the lines on the other side have frequent stations and junctions, all of which must be provided with interlocking at the outset, leaving only a minimum number of extra towers necessary to quite evenly block out the road for the same purpose of keeping trains well and safely separated. Such a system of blocking is positive, and is all done by semaphores ; but not so with us, though the automatic is intended to accomplish

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much of the same kind, and with rail circuit it may be safely claimed to do more by continuing it through and under the interlocking application; yet it must ever continue to do its work with a permissive in the place of a positive value. Its use is to indicate danger, and this only; and its position at safety is not an order to proceed, only the permission.

With the semaphore this style is changed, a signalman in attendance at the tower directs by the aid of the machine all the movements which involve conflicting routes. The geography of the road, known to every competent runner, includes at this place a possibility of trains crossing his route, either those of other lines or some switching or new direction on his own line. This district through which he is to pass is guarded by stop signals, semaphores horizontal. Every avenue of entrance either by side track or back up against traffic right of way on the main tracks should be closed by a stop signal. The whole inclosure is guarded track, and dangerous for any trains without the right to enter, as shown by an all clear signal, but the stop signals are here for a more definite purpose than the automatic, which with its unexpected red signal may be found protecting a broken down train on the road. The automatic gives warning of the unusual condition of danger on the track of an approaching train, but when the interlocking stands guard the danger exists continually like that of a river running around our city, "Stop unless ordered to proceed." The runner no longer approaches an interlocked district prepared to run until something unusual prevents it, as at the automatic signal, but he now prepares to come to a stop at a definite point unless he can discover an all-clear semaphore signal. The home signal should be located at the fouling point first reached, that the engine may come close to it but not pass it, while the red automatic signal and the horizontal distant semaphore both agree in indicating that the train may proceed only with caution, possibly protecting a train by so doing. The all-clear automatic has no reference to the next signal ahead, but the all-clear distant semaphore furnishes a large assurance that the next home signal has been pulled and is now open. Again the semaphore home signal may be open for an approaching train—when it should be closed if the signalman had not failed of his duty to protect a train which had not passed out of the district—and a red automatic signal covering the same district may be used to warn the approaching train of such a condition. When by reason of close proximity of interlocking machines, the distant signal for one tower extends back to the next tower, it is usually placed on the same post as carries the home signal for the same route at the latter tower; but the home signal being the controlling sentinel at that place, is placed the higher on the post, and the two signals are so slotted together that although the tower man may pull his distant signal it still will remain horizontal unless the other tower man lowers his home signal. At a succession of towers provided only with home signals, trains could hardly approach and pass through curved yards at a speed much over 20 miles per hour, but when in addition distant signals are provided with reasonable laps, unlimited speed may be maintained.

It is of primary importance that the signal operator should always have power to put back the signal to its normal position as soon as he pleases, even to the extent of throwing up a signal in the face of an approaching train, which might be necessary on account of the sudden development of an obstruction in that route. Any system of signals which is arranged to interfere with this freedom is faulty and should not be used. Only this modification is permissible, namely, that with a succession of signals on one route under the signalman, the order of preference will have to be observed, the last signal opened, such as the distant signal, will have to be the first one put back.

The signal should be returned to its normal position as soon as the engine passes. 1st. In order to check any too closely following train. 2d. In order to be prepared to give a new route to any train which may appear on some other route and to prevent the delay which might be caused by a freight train stealing into the first named route, when by right of class of train the train just appearing on a conflicting route should be passed.

Home signals should be placed as the name indicates, just as close to the fouling point as the ground will admit. There is no good reason for making any allowance for room or leeway space between signal and fouling points. Enginemen should approach the interlocking, prepared to stop at the proper places and draw as near to them as possible, so as to expedite their passage through the interlocking as soon as the signal is given them by shortening the distance to be run. Long trains take advantage of this to get well under the protection of the distant signals. Interlocking makes the neatest application when the fouling space or interlocked district is the shortest, and an ideal application would be a fouling space reduced to a single line crossing the railroad. The nearest approach to this exists when the interlocking simply covers the right angle crossing of one railroad with another.

Many existing applications of interlocking are faulty because of inconvenient arrangement and location of the switches. An intelligent study of a district to be equipped will often discover rearrangement of connections which can be made so as to reduce the outlay, and greatly facilitate the train movements. Slip switches with crossing frogs often save a wonderful amount of valuable room, and develop facilities which cannot be obtained in any other way. For example, see the yard of the Grand Central depot in New York, under an interlocking machine of 116 levers.

One of the disadvantages of long distances in the interlocking exists when a route starting from a home signal includes a facing point switch a long distance ahead, such a switch, although guarded by a detector bar and facing point lock, may still be subject to the possibility of being changed by the operator after the home signal has been passed by the engine. Conflicting routes which do not always conflict are very common under these stretched out districts, so that sometimes a train may enter and stop for a station or other cause and yet not foul all the other routes. It may become desirable to hold the train there and give another train a route, therefore this rule: *an engine which stops inside the interlocking loses its rights if its signal is put up, and may not move again in any direction without a new signal.*"

The signal should occupy a position directly in the line of view of the engineman as he nears it, and if necessary, bridges should be constructed to attain this object, so as to bring the signal directly over the right-hand rail. Only in very exceptional cases is it permissible to place the home signal of a speed route off one track to the right when that track happens to be a siding not connected with the interlocking. When from the route of approach a number of routes diverge, it is best to unite all the signals of the diverging routes on a post located at the first fouling point, and arrange the signals in regular order from the topmost down, corresponding to the most extreme route to the right, followed by the next one to the left, and so on. This rule is arbitrary and might be just as reasonable if the left-hand route was signaled at the top of the post, but natural custom has established this method. It is of great convenience to have the rule strictly adhered to in all cases, and once understood no trouble follows. This rule has had its opponents, who have argued that the top signal should always be taken to apply to the most important route, but though the advocates of such practice have argued in its favor for the earlier and very few applications of interlocking which may be introduced, they have, when they came to consider the possibilities of most extensive outlays, and four track junction points, and large terminal grounds,

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yielded their first desires to the prevailing practice in conformity to a rule requiring no exceptions.

It is far better, in order to favor such speed service by some prominent signal, to resort to the practice of emphasizing the signals for speed routes. This may be done in various ways. 1st. By varying the sizes of the semaphores. This can be made very conspicuous and still remain in proper order on the post. Give the speed route a full-sized arm and give the siding or branching routes small arms. At night, light the speed signals with bull's-eye lanterns and light the small arms with reflected light. 2d. Make the use of the distant signal dependent solely and alone on the use of the home signal for the speed route, and oblige all trains for the slow routes to pass the horizontal distant signal.

THE GREAT BRUSH DYNAMO.[1]

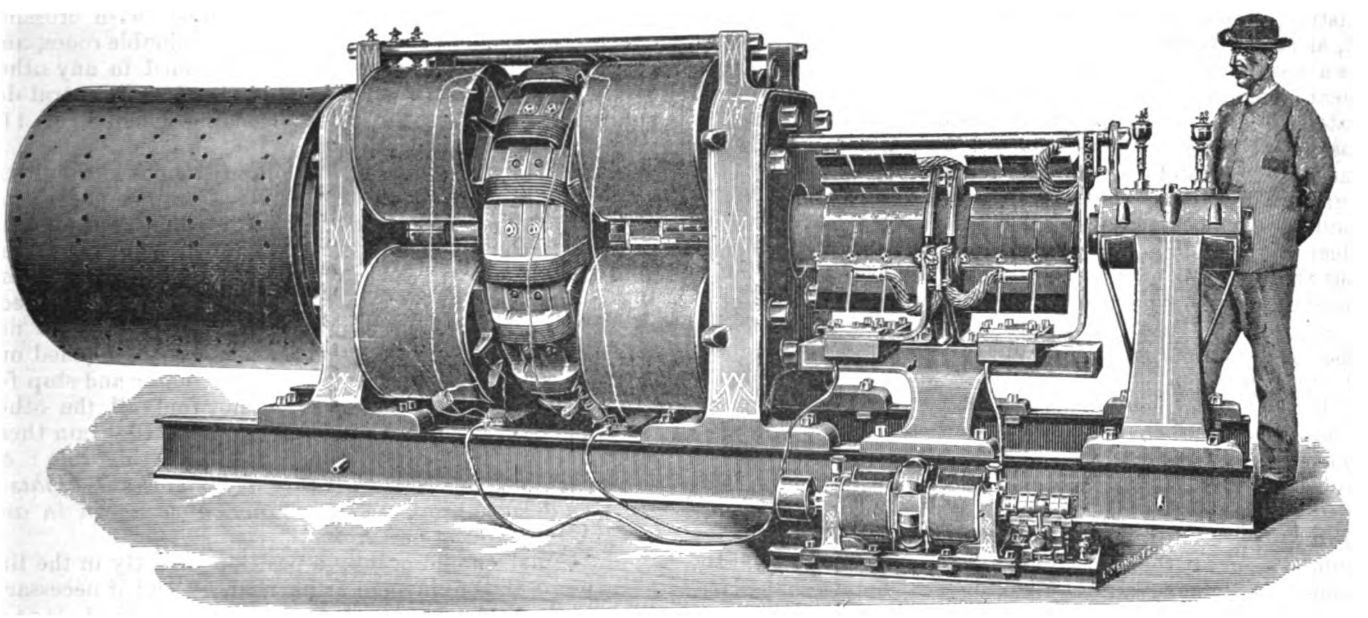
BY DR. ROBT. H. THURSTON,

Director Sibley College, Cornell University.

The process of reduction of aluminum and other metals, and production of alloys, invented by Messrs. Eugene H. and Alfred H. Cowles, and perfected with the assistance of Professor Mabery, of Cleveland, O., has attracted the attention of engineers, as well as of men of science, not only on account of the ingenuity, simplicity, and effectiveness of the process itself, but also, and probably quite as much, because of its bringing into use the voltaic arc and dynamo-electric machines of exceptional and enormous power.

The writer, on the occasion of a recent trip to the west, was, on his return journey, so fortunate as to be able to stop in Cleveland long enough to witness the operation of the process, and to be present at the first trial of the great dynamo recently completed by the Brush Electric company for the Cowles Electric Smelting and Aluminum Co. The occasion was so interesting, and the facts developed so striking and probably important, that it has been thought worth while to present a very brief account of them to the members of this section of the American Association for Advancement of Science.

The Cowles process, as will be remembered by those who listened to the interesting account given the association at the Ann Arbor meeting of 1885, and published in the *American Journal of Science* for October of that year, or who have read the interesting paper of Mr. Eugene H. Cowles, read at the stated meeting of the Franklin Institute, in January, 1886, and published in the Journal for February, 1886, consists in the passage of a powerful current of electricity from a "dynamo" through a mass of ore mixed with carbon and other material forming the "charge," until the action of the heat, and possibly of the electrical force, causes a reduction of the ores and the formation of an alloy of the metals so reduced. The apparatus consists simply of a powerful dynamo-electrical machine, connected with a pair of carbon electrodes of correspondingly exceptional size, these electrodes being enclosed in a furnace of brick work, lined with the most refractory available material. The Cowles company have several dynamos, all of large size, but it is the intention of the writer to describe but one, the latest built and the largest. The next smaller, which was until recently considered a very powerful machine, weighs about two tons and a half, is driven at 900 revolutions per minute, and produces a current of 1,575 amperes, with an E. M. F. of 45 volts. These machines are "shunt-wound" and very nicely proportioned under the direction of the inventor, Mr. Charles F. Brush, whose interest in the work induced him to give to their construction his personal attention. The largest machine, recently completed, and under test at the time of the visit of the writer to the works, weighs 21,900 pounds, (9,934 kgs.) a so-called 42 inch (1,060.6 mm.) machine, the armature having that diameter. The armature contains 1,600 pounds (725.7 kgs.) of iron; it carries 825 pounds (378 kgs.) of copper wire, while the field magnets are wound with about six times that weight, 5,424 pounds (2,641.8 kgs.).



THE GREAT BRUSH DYNAMO.

The armature of this great dynamo consists of 16 bobbins, each carrying 21 turns of best copper wire, two strands lying side by side, the wire being 0.35 inch in diameter (8.89 mm). These 16 bobbins are operated in multiple arc, thus giving 32 strands of copper wire, of the diameter above stated, and about 65 feet (19.8 m.) long. 16 copper bars carry the current from the bobbins to the commutator, each bar being one inch by one-half inch (25.4 mm. by 12.7 mm.) in section. The two commutators are coupled in multiple arc.

The field magnets are eight in number, and consist of a cylindrical cast iron core, 11 inches (279.4 mm.) in diameter, by 16 inches (406.4 mm.) in length, and wound with 30 layers of 102 turns, each, of copper wire, 0.134 inch (3.404

1. Read at the Buffalo Meeting of the American Association for the Advancement of Science, August 19, 1886, and revised for publication in the *Journal of the Franklin Institute* by the author.

mm.) in diameter ; all the eight wires are coupled in multiple arc as in a shunt field. Thus combined they have a resistance of about one ohm, total, cold. The pole pieces are of peculiar form, and fitted carefully to the field.

The driving shaft, carrying the armature, is 13 feet (3.962 m.) long, and five and one-half inches (139.7 mm.) in diameter in the main bearing ; it is made of open hearth steel, furnished by the Otis company. The machine is driven by means of a 44 inch (1,117.6 mm.) double belt, turning a 40 inch (1,016 mm.) pulley on the armature shaft. The machine occupies a space on the floor about 15 feet (4.572 m.) long, and four feet (1.219 m.) wide, and stands about five feet (1.52 m.) high.

This dynamo was calculated to furnish a current of 3,200 amperes, with an electromotive force of 80 volts, with a normal maximum current in the field of 80 amperes ; the speed of rotation not to exceed 600 revolutions per minute. Its actual speed was a little above 400 when doing the full amount of work demanded. The maximum field is thus obtained with but about two and one-half per cent. of the normal current (3,200 amperes), and falling to one per cent. when less E. M. F. is needed. When in operation, the writer found no observable heating in any part of the machine, and the bearings ran perfectly free from heating or cutting. The efficiency of the machine must be very great, as, after its longest run of two hours, the armature was cool enough to handle with perfect comfort. The writer could bear his hand on every accessible part of the machine, which included all parts liable to any serious heating. The belt was new and stiff, and occasionally slipped as the limit of the power of the machine was approached ; but that was a fault which a little work would cure, by making the belt flexible and giving it a better bearing on its pulleys. Had the engine driving it been of sufficient power, it was evident much more work could have been done than was actually performed on the trial. It was judged that it might have been driven up to 300,000 watts with safety. The conductors provided, and the resistance coil used in measuring the power developed, were, however, about at the limit of their endurance ; as it was, the former heating until they were blue, and the latter requiring constant watching and cooling by application of water. The maximum reached was 249,000 watts, or 334 electrical h. p., the engine probably developing not far from 400 indicated h. p. No indicators had been fitted, and it was impossible to measure this factor. The limit of its power was reached, however, and the power of the dynamo could not be tested to its maximum. The speed intended was, for the dynamo, 430 revolutions, but at 80 volts it could not be driven by the engine up to that speed.

The dynamo was built, complete, in all its details, from the specifications of Mr. Brush, and without preliminary experiment, and, when tested, was found to require no alterations of any kind, and came fully up to the requirements of the specifications and contract. Its capacity is very much greater than that of any machine yet built in the United States, or in the world. Its successful construction is considered by its designer to indicate that it is possible to design a machine of any desired size and power, with perfect confidence that it will come fully up to the calculated performance. No limit is to be seen, as yet, to the size and power of the machines, if properly designed. Their construction is a matter of definite calculation, and is to-day independent of direct experiment. The fact that a dynamo may be precisely designed and proportioned for any kind and amount of work that may be demanded, for any purpose whatever, without limit, so far as can be to-day perceived, is one of the most interesting and important revelations of recent work in this field. The fact, also plainly shown by the experience of the Cowles company, in the use of these enormous machines, that the larger the machine, the higher the duty of the plant, is no less interesting and important. The economy secured in the production of their aluminum and other alloys, by the increased size of the later dynamos put in operation, is so great as to be a very valuable factor in the operation of the business, each new and larger machine very considerably reducing the price at which the metals can be put on the market.

EXPERIMENTS WITH 42 INCH BRUSH MACHINE. JUNE 25, 1886.

Revolutions per minute.	E. M. F. Volts. in ext. circuit.	Amperes in ext. circuit.	Amperes in field shunt.	Watts in ext. circuit.
428	78	1,000	33¼	78,000
424	68	2,000	30½	136,000
423	56	2,500	27½	140,000
420	66	2,600	37½	171,600
418	72	2,640	46½	190,080
410	76	2,700	58	205,200
420	94	2,040	89	191,760
412	88	2,450	85	215,600
410	86	2,700	83	232,200
410	85	2,800	82	238,000
405	86	3,200	80	249,000
423	56	2,700	29	151,200
428	54	3,150	35	170,100
428	62	3,400	45	210,800
423	66	3,400	50	224,400
423	68	3,400	52	231,200
428	52	3,000	33	156,000
421	46	2,950	28	135,700
421	36	2,620	21½	94,320
421	32	2,500	19	80,000
421	26	2,300	16	59,800
421	22	2,100	15	46,200
421	19	1,850	13	35,150
431	100	0,000	76	
431	105	0,000	100	

The tabulated statement, shown herewith, presents the figures obtained at the trial of the 10 ton dynamo above described, and will repay careful study, as they exhibit the effect of variation of speed, of variation of current in the field shunt, and of electromotive force, in the production of energy in the external circuit. The highest power attained on this occasion was, as shown in line 11 of the table, 249,000 watts, the speed of revolution being 405 (25 turns below the regular speed), the electromotive force being 83 volts (three above the standard), and the current measuring 3,200 amperes. The electromotive force in the shunt coils was 80 volts. The heaviest current measured 3,400 amperes, the electromotive force being 68 in the main current and 52 in the shunt, the current energy measuring 231,000 watts at the terminals. At the standard speed of rotation, the circuit being broken, the measured electromotive force was 100 volts.

This remarkable and powerful machine was driven, at the time of the visit of the writer to the works, by a Corliss engine through a heavy counter shaft, the engine belt being carried over the belt from the jack shaft pulley to the machine. This arrangement is an unusual, but perfectly practicable one, and, in this case, worked admirably. It was occasionally necessary to readjust the position of the dynamo, as the belt, which was new, stiff and smooth, stretched more on one side than on the other ; but this stretching will soon cease, probably has ceased, and, as the belt becomes more flexible and more perfectly fitted to its pulleys, and as it takes its maximum stretch, it is evident that it will work with perfect accuracy and will be competent to transmit any load that the dynamo can be expected to throw upon it.

The current from the machine to the furnace was conveyed by ropes of fine copper wire, or by conductors made up of several heavy wires. At the furnace, they were connected to the terminals, which latter were of bar copper, apparently about two and one-fourth inches in diameter, armed with four carbons each, the latter of about the same diameter and four feet long. Between these was arranged the conducting material which furnished the incandescent bed in which the operation of reduction was carried on. This process is not, as is very often assumed, by professionals as well as non-professionals, an application of the voltaic arc to the production of high temperatures. Such an application was made by Sir William Siemens and by other experimenters from the time of the discovery of the intense

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heat of the arc; but it is, in the Cowles process, an application of the incandescence, as distinguished from the arc system. A connection is established between the carbon terminals, by means of a mass of carbon and other material, which mass is carefully kept continuous and incandescent throughout the whole operation. This is essential both to the success, actual and economical, of the process, and as distinguishing it from the older and wasteful systems of melting. By this system, the intense, the immeasurable heat of the arc is tempered and diffused throughout a large volume of incandescent material, and becomes adjustable and capable of regulation with comparative ease and exactness. Such control is thus secured as to make it convenient and economical in application to the reduction of ores and the melting of alloys and metals. Actual contact carries, everywhere, a very large proportion of the current, and the heat is distributed among numberless little particles of highly heated carbon, which lend each its share to the numberless particles of the compounds to be reduced.

It is probably only by some such application of the electric heat that corundum can be made to surrender its aluminum to form an alloy with copper. It has been stated recently, in the discussion of this process, as described by Dr. Mehner, before the Association for the Advancement of Science in the kingdom of Prussia, at the Berlin meeting of the present year, that this reduction had been accomplished in a furnace heated in the ordinary manner; but it would seem that this must be a mistake; since alumina is one of the most refractory substances known in nature; it is said to be even more so than the materials of our furnaces and of our crucibles. The Messrs. Cowles have subjected it to the highest temperatures that a Dixon crucible would bear, without being able to reduce it or to melt it, in the presence of carbon and copper. Further, it would be probably impossible to successfully maintain a reducing flame, if that were attempted, or to avoid the reoxidization of the metal were its reduction primarily possible. The reducing temperature of the compound is above the temperature of volatilization, also, of the pure metal, and this would make it improbable that its reduction in this way should be successfully performed, far less with commercial success. The volatilized metal would rapidly escape from the Siemens furnace or from any other familiar form of furnace, while no other process than that above described would be capable of forming the volatilized metal in a closed furnace. In the Cowles furnace it is practicable to reduce alumina either with or without the presence of copper or other alloying metal, and one of the first intimations of the production of the working temperatures in that furnace is the appearance of fumes, indicating some volatilization to be produced. As ordinarily conducted, this is not important in amount. Alloys of aluminum have been made in this furnace with nearly all familiar metals, a proof that copper, at least, is not essential to secure the reduction. So far as the writer has been informed, this is the only process by which reduction of this metal with carbon alone can be accomplished. The production of the metal commercially, in this manner, is expected to soon become an accomplished fact. The manufacture of the aluminum alloys has now for some time been successfully carried on, the cost of the aluminum in the alloy having been reduced to a small fraction of the price for which the metal is sold as made by the older methods. The Messrs. Cowles and Professor Mabery have opened a new and broad field of experiment, and no one can surmise, even, what may become of the infinite range of possibilities so presented.

THE WESTINGHOUSE ELECTRIC LIGHTING SYSTEM.

Much interest has been excited in electrical circles by the editorial announcement made in our last issue respecting the success of experiments recently made with the system of electrical distribution by induction, which is about to be introduced by the Westinghouse Electric Company of Pittsburg. This interest has been heightened by statements which have appeared in the public press purporting to set forth some of the results which had been attained. Having been permitted to examine the apparatus in actual operation, we purpose at an early day to present our readers with a detailed description of the plant; meanwhile a brief statement of the facts, which may be relied on as accurate, so far as it goes, will doubtless be of interest. The test which we witnessed was made in Pittsburg. The dynamo was located in the factory of the Westinghouse Electric Company on Duquesne Way and Garrison Alley, Pittsburg, and the lamps were situated at a distance of 3 miles from the generator in a suburb of the city, best known as Lawrenceville. The conductor used was No. 4 B. W. G. copper wire, 6 miles in length out and back, and having a resistance of 6 ohms. The generator is of the alternate class, and was originally designed by William Stanley, Jr., some of the details of the present model having been worked out by Messrs. Westinghouse, Shallenberger, Byllesby, Schmid, and others. It is a remarkably well designed, efficient and handsome machine. The body of the armature is cylindrical, 23 inches in diameter and 12 inches face, and is formed of discs of iron magnetically separated from each other, the conducting wire being wound in flat coils upon its face. The field magnets, 16 in number, are arranged in a circle, with their poles facing inward towards the armature and in close proximity thereto. The dynamo is driven at the rate of 1,080 revolutions per minute, thus giving 17,260 alternations of the current per minute or 288 per second. The weight of the entire machine is about 7,000 pounds, and the total weight of copper wire on the armature and field magnet about 800 pounds. The potential at the terminals of the dynamo when running is maintained at about 1,100 volts. An independent exciter is employed for the field, consisting of a small Stanley direct current dynamo of 150 volts and 10 amperes, driven at 1,800 revolutions per minute. The alternate dynamo and exciter are both belted to the shaft of an 18 by 16 Westinghouse automatic engine, rated at 200 h. p. and making 276 revolutions. The potential at the terminals of the main conductors, 3 miles from the dynamo, is 1,000 volts, showing a drop of only 10 per cent. The inductoriums, or "converters," as they are technically called, are placed at the point of consumption, and have their primary wires attached to the main conductors and their secondary wires to the leads which extend through the premises to be lighted and to which the lamps are attached in the usual manner. In the present installation each converter contains 112 pounds of iron and 43 pounds of copper, and is capable of supplying 50 16-candle incandescent lamps at a potential of 100 volts. In one long continued test 850 lamps and in another 1,000 lamps were lighted to their full candle-power on this circuit, and the high commercial efficiency of the system as a whole may be estimated by the result which was obtained of a little in excess of 8 lamps per indicated horse-power.

It will be seen from these data that not more than 1 pound of copper per mile is required for each lamp in this system. It is easy to estimate the immense saving in the cost of installation of an electric light plant which is capable of being realized by the use of this invention. The system of the Westinghouse company as now perfected is based upon the fundamental patents of Messrs. Gaulard and Gibbs whose apparatus has for some time been in successful use, though only to a limited extent, in England. Many modifications and improvements have been added to the original system by Mr. Westinghouse himself and by Messrs. Stanley, Shallenberger, and other electricians of the company. The remarkable results which we have above chronicled are in fact the outcome of more than a year of elaborate and costly experimentation by a number of the ablest electricians in the United States. We shall publish further details of this interesting system at an early date.

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ABSTRACTS AND EXTRACTS.

ELECTRICAL CONDITIONS OF THE HUMAN BODY.

THE Lumleian lectures, now in course of delivery before the College of Physicians, by Dr. W. H. Stone, are attracting unusually large audiences. Their subject is "The Electrical Conditions of the Human Body." Dr. Stone was one of the first to call attention to the importance of determining accurately the physical constants of the agent electricity when employed in physiological investigation. In these lectures he has shown that most of the contradictory results obtained by the earlier investigators are due to the neglect of this precaution. The enormously high resistance of the epidermis was demonstrated; and, when this was eliminated, the average resistance to a continuous current from the ulna at the wrist to the malleolus at the ankle, was shown to be about 1,170 ohms, due allowance being made for the errors caused by polarization, according to the ingenious method first devised by Sir Henry Mance for the Persian gulf cables. Some entirely new experiments were detailed, and in part repeated before the audience, showing that the human body could be charged and discharged like a secondary battery. An electromotive force of two volts was employed, and curves showing the rate of discharge were exhibited. A discharge current of 60 micro-amperes at first, under an electromotive force of about one volt, sank to 48 in five minutes, and remained at that for some hours. The resistance offered by the body to an induced current was stated to be only half that offered to a continuous one. An ingenious speculation was hazarded as to the possibility of the human nervous system distantly resembling a duplexed telegraph cable, in which a transmitted impulse is balanced and inhibited at the sending station, but unbalanced and exhibited at the receiving station.—*Science*, London correspondence.

MAGNETIZATION OF IRON AND NICKEL.

SOME interesting details concerning the behavior of iron and nickel when magnetized are summarized by Mr. Shelford Bidwell, F. R. S., in a paper in the *Philosophical Magazine*, which embodies some of his own experiments. A nickel wire, when magnetized longitudinally, by insertion in a helix through which a current is passing, contracts, and, as the magnetizing force increases, so does the contraction. On the other hand an iron wire at first elongates; the elongation reaches a maximum, and then commences to diminish in length, until the original size is reached; and, lastly, commences to contract as the magnetization gets greater. When the iron wire is placed under tension by hanging weights from it, the maximum elongation due to magnetism is reached with smaller magnetizing force than when the iron is not under tension. An iron ring behaves in a similar manner; its diameter increases with weak magnetization, and diminishes with greater magnetizing forces. If a nickel wire, which is already longitudinally magnetized by means of a helix, have a current passed through it so as to become also circularly magnetized, it will be observed that the free end begins to twist, the direction of the twisting being the same with all degrees of magnetization. An iron wire, treated in the same way, at first twists in the opposite direction to that of the nickel wire; the twist in this direction reaches a maximum, then diminishes to zero, and finally the iron wire turns in the same direction as the nickel wire. These properties, which have an important bearing on the theory of magnetism, may possibly become of practical utility.

REPORT ON THE EXPERIMENTS OF M. MARCEL DEPREZ RELATING TO THE TRANSMISSION OF POWER BETWEEN CREIL AND PARIS.

BY M. MAURICE LEVY.

A COMMISSION composed partly of members of the Academy and partly of engineers has, at the request of Messrs. Rothschild and in agreement with our colleague, M. Marcel Deprez, accepted the task of verifying the results obtained by him in his experiments on the transmission of power between Creil and Paris.

This commission, the honorary presidency of which has been assigned to M. de Freycinet, member of the Academy, and the acting presidency to the perpetual secretary, M. J. Bertrand, has entrusted the care of preparing and editing its report to a subcommittee composed of M. J. Bertrand as president, M.M. Becquerel, Collignon, Cornu, Laussedat, Maurice Lévy, and A. Sartiaux, with M. Léon Lévy as secretary.

On the advice of the perpetual secretary I have the honor of rendering to the Academy an account of the proceedings of this sub-committee, of which I have had the honor of being the reporter.

For this purpose it is necessary to recapitulate briefly the object aimed at by M. Deprez, and the essential arrangements of his project.

The object has been essentially, taking 200 h. p. at the station of Creil, on the North of France Railway, to transmit them electrically to the terminus at La Chapelle, a distance of 56 kilometres, with an industrial yield of 50 per cent.

The motive power was to be supplied at Creil by two locomotives and transmitted by means of a single dynamo as generator. It was to be received at Paris by two machines as recipients.

From reasons of an administrative nature, and independent of the wish of M. Deprez, only one of these two machines having been constructed, it was only possible to receive 50 h. p. at Paris, taking 100 at Creil.

Causes of the ill-success at first obtained.—The experiments, arranged with the co-operation of a commission of engineers (MM. Collignon, Aron, Baron, Cail, Constantin, Delebecque, and A. Sartiaux), were carried on from the month of November, 1885. The outset, it will be remembered, was not fortunate. It will, however, be useful to remember this fact, that the failures encountered had all the same cause: the faulty or too imperfect execution of the rings of the generator.

The generator at Creil, like the recipient at Paris, required two Gramme rings, mounted on the same axle, and connected in series.

In the Gramme machines the core of soft iron upon which the circuit of the ring is coiled is most frequently of iron wires.

M. Marcel Deprez prefers to adopt round plates of thin sheet-iron, insulated from each other by means of paraffined paper.

In the first rings manufactured, these discs were certainly insulated in this manner, but imperfectly. As for the connecting-rods which traversed all these discs they had been merely covered with a layer of shellac-varnish, which was sufficient electrically but not mechanically; the varnish was broken whilst the rods were being driven in. Thus in the first attempts there were produced, in the entire mass of the iron, powerful Foucault currents, which absorbed almost the entire motive force. The yield was almost nil.

First reparation of the rings of the generator.—It was then determined to make new rings with cores of iron wire. The yield was then better. But as it had been thought sufficient to coat the wires with two layers of silk and one of cotton without the whole being saturated with gum-lac, and as further, the wrapping of the wires had not been carried out so as to avoid great differences of potential between adjacent wires, frequent damage took place.

These are the rings which were in action on the visit of the Academy of Sciences, December 5th last.

This day squally weather had, as it is known, entangled the wire of the line with the telegraph wires. There resulted discharges which were felt at La Chapelle and at the telegraph office of the artillery at Saint Denis, where two instruments were burnt. The rings were rendered useless, and the experiment was forcibly interrupted.

Final reparation of the rings of the generator.—In consequence of this incident M. Deprez decided to reconstruct his rings afresh, returning this time to his first idea of forming the cores and discs of sheet-iron, but taking care to enclose each connecting rod in a tube of hardened caoutchouc.

At the same time the diameters of the rings, designed at first as of 1.40 metre, were reduced to 0.78 metre, and the pre-arranged speed of 400 revolutions was prudently reduced to 200.

The bobbins were made in segments, each occupying one-seventh of the circumference, and wrapped with layers of a single continuous wire, so that only wires slightly differing in potential could come in contact.

On the other hand, for convenience in manufacture the sheet-iron cores were no longer made each of a single piece, but of two segments, one of which occupies six-sevenths of the circumference, and leaves, consequently, a gap equal to one-seventh, by which means six of the seven bobbins forming wrapping of the ring can be strung as beads are strung on a necklace.

Thus the sixth-sevenths of the ring are formed. The last seventh is placed entirely with its core, like the key-stone of an arch.

These arrangements have, from an industrial point of view, the precious advantage of not merely simplifying the first

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manufacture of the rings and of rendering them very strong and enduring, but also of permitting the quick repair of any damage or injury which may occur.

If a wire happens to be burnt it is sufficient to replace the segment of which it forms a part, and as the segments are all alike, a certain number are made beforehand, forming exchange pieces which may be introduced without difficulty and without having to re-make the entire ring.

With the introduction of these various improvements the epoch of fruitless trials and of incessantly recurring accidents came to an end, and there followed the epoch of prudent, slow, but certain advance.

The new rings have acted since February last in the most satisfactory manner, working for 5, 6, and even 9 consecutive hours without accidents and without becoming heated above 47° C.

This figure 47° does not result from a direct thermometric measurement, which it would be impossible to execute in the deep mass of the wires. But the resistance of the wires, which when cold is 38 ohms, rose after a day's working to 45 ohms, an increase of 7 ohms or of $\frac{7}{38} = 0.184$ of its value. But the resistance of copper increases by about 0.40 of its value for a rise of temperature of 100°, whence there results here an increase of temperature of $\frac{100° \times 0.184}{0.40} = 46.5°$ or about 47°.

The inductors of the generator.—The inductors of the generator are formed of 8 horseshoe electro-magnets placed in the planes passing through the axes of the rings diametrically opposed to each other two and two, so that their polar expansions embrace nearly the circumferences of the rings. There is certainly in the machine at Creil a little too much deviation between the circumference of the rings and the polar surfaces of the inductors. By means of a little more precision in the construction this distance might be diminished, which would increase the effects of the magnetic field.

The use of two rings with horseshoe electro-magnets is very advantageous, as by this arrangement all intermediate poles are avoided. The only polar surfaces existing are those which match the circumference of the rings so that all the poles are completely and perfectly utilized.

This arrangement had been already adopted by M. Marcel Deprez in the excellent machine which served in his former experiments at the terminus of the Northern Railway. There, however, he employed only two electro-magnets instead of eight.

It may be asked which of the two arrangements is preferable. Is it advantageous or inconvenient to multiply the number of the electro-inductors?

The question is put thus:—

If we wish to devote to the inductors a given length of copper wire of a section, and consequently of a resistance, likewise given, is it preferable to distribute this wire over a great number of electro-magnets or to adopt the contrary arrangement?

The theory of solenoids decides in favor of the latter solution, since for a solenoid of a given length with a wrapping of a given volume the wire expended increases only in proportion to the radius of the solenoid, whilst the polar surfaces obtained increase as the square of this radius.

It is therefore, suitable, and this has guided M. Deprez, in the construction of his machines, to employ, in as far as the conditions of the construction permit, a small number of large electro-magnets, so as to obtain a cheap magnetic field. We shall see, further, that in this respect experiment fully confirms the previsions of theory.

Dynamo recipient machine.—The recipient machine placed at La Chapelle is of rather smaller dimensions than the generator, since it receives only about half the force consumed at Creil. The cores of its rings are of iron wire, because it has always worked very well, and there has consequently been no occasion to substitute for the wire sheet iron discs, as has been done in the generator.

Save for these differences the two machines are conceived in the same spirit.

Transmitting wire. Inutility and possible danger of insulation for its entire length.—The distance of transmission being 56 kilometres, the transmitting wire, going and returning, has a total length of 112 kilometres. It is of siliceous bronze, and is five millimetres in diameter. Its resistance is 97.45 ohms, that is, that of an ordinary telegraph wire of about 10 kilometres in length.

In the outset it was coated for two-thirds of its length with hemp steeped in resin, and was itself enclosed in a leaden tube.

This precaution did not obviate the accident of which we spoke above on the occasion of the visit of the Academy. In fact, if a blast of wind drives the telegraph wires against the wire of the line, the violence of the shock may tear the lead and produce in consequence the contact which the lead tube was to prevent.

This precaution is, therefore, of no use, and as the weight of the lead increases the flexion of the wire, unless it is submitted to an elastic tension capable of breaking it, it has simply the effect of facilitating the contact of different wires and of thus multiplying accidents.

Further, hemp placed between the copper and the lead may, in moist weather when the insulation of the line is not perfect, play the exact part of the di-electric of a condenser. *e.g.*, that of the glass placed between the inner and outer coatings of a Leyden jar, and the result may be dangerous condensations.

Thus, from all points of view, the precautions taken to avoid accidents ran counter to their object. There is room to think that the best way is to leave the wire bare. Hence there will naturally result an important economy in the cost of the installation, and every economy which is not contrary to public safety ought to be accepted and encouraged since it is a facility given to the industrial applications of the transmission of power.

Precautions proposed for the wire.—The only precautions which it seems useful to take with the wire are the following:—

1. To insulate it thoroughly at its entrance into and its exit from the machines, *i.e.*, where it is within reach of the hand.

2. To place it everywhere else at such a height as to be inaccessible.

3. To place it at a great distance from telegraphic, and especially from telephonic wires, so as to avoid absolutely, not merely contact, but any effect of induction.

4. A distance of ¾ to 1 metre appears sufficient if, as in the Creil experiments, a return wire is employed.

If, as it would be very desirable and important, and as we strongly wish, experiments of transmission are undertaken without a return wire, the distance to be observed will be much greater, and can only be determined by experiment.

Exciters. Magnetic fields.—The two dynamos at Creil and La Chapelle are not self-exciting. Each of them is excited by a Gramme machine at low tension. That at La Chapelle has received the double wrapping devised by M. Marcel Deprez, one of the two wrappings being in derivation so as to maintain the difference of potential at the extremities of the machine sensibly constant, in spite of the differences of resistance which may be produced in the circuit.

That at Creil is an ordinary machine.

We have thus three distinct electric circuits:—

1. A local circuit at Creil formed by the exciter and the inducers of the generator.

It is the current of this circuit which produces the magnetic field at Creil.

2. A local circuit at La Chapelle formed in the same manner by the exciter and the inducers of the recipient.

The current of this circuit produces the magnetic field at La Chapelle.

3. A general or junction circuit, into which enter the line and the rings of the generator and the recipient machines.

Of the currents traversing these three circuits the last only, that of the line, is at a high tension.

These machines might have been arranged in such a manner as to excite themselves, and have in consequence merely a single circuit comprising the line and the inducers and induced parts of the two machines. Thus the two exciters would have been suppressed, and the work expended in setting them in action would have been saved.

But the magnetic fields being then in the high tension circuit, which produces the work to be transmitted, would have been effected by any sudden change occurring in the resistances to be overcome, and these modifications would have produced in the great metallic masses which the inductors comprise abrupt effects of magnetization or demagnetization, involving in turn violent electric reactions dangerous for the rings.

We may give account of these effects by the following fact:—

If at La Chapelle, at the end of the operation, that is at the moment when every current has just ceased the circuit of the inductors is broken, there is produced a violent spark, and that even five or six seconds after the current has been interrupted.

This depends on the induction due to the demagnetization of the wire. The magnetic field passes in a few seconds from the considerable value which it had during the operation to zero.

The velocity of demagnetization is therefore extremely great, and produces very considerable induction effects. The same result would occur *a fortiori* at Creil.

It was therefore necessary, in spite of the increase of expense resulting, to form magnetic fields by means of low tension currents distinct from the current of the line, and participating only in an insensible measure in the variations which the latter undergoes in consequence of changes in the resistances to be overcome.

The necessity of exciting the machines by currents generated outside themselves occasions no difficulty at Creil, where motive power is available. It is not the same at La Chapelle.

At Creil the locomotives set in motion, by means of a pulley transmission, the axle of the rings of the generator, which in turn impels that of the exciter.

The movement of the exciter determines the local current and consequently the magnetic field at Creil.

The movement of the generator extending into this magnetic field determines the current of the line by induction. This current passes into the rings of the machine at La Chapelle, but as here there is hitherto no magnetic field, since the local circuit of

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La Chapelle is separate from the line and receives nothing, the recipient rings remain motionless notwithstanding the current which traverses them.

There is, therefore, no transmission of power, but at the most of available energy. To transform this into effective work, it is necessary to create and maintain the magnetic field at La Chapelle. The most natural means would be to have there a small steam engine impelling the exciter. This method was employed at the outset, but from an industrial point of view it is absolutely inadmissible; for if we pretend to distribute power we must not begin by requiring those who are to receive it to have each a small steam engine in his house. This would be as if to be able to utilize a supply of gas it would be necessary to have small domestic gasworks.

But this difficulty is only apparent, and M. Deprez evades it by the following very ingenious arrangement:—

The axle of the recipient is placed in mechanical communication with that of its exciter by means of a pulley.

On the other part. when we begin the transmission, the local circuit at La Chapelle is brought provisionally into the circuit of the line by means of a commutator. Then the current of the line arriving at once in the rings and the inductors of the recipient, the rings are put in motion; their movement is communicated to the exciter, and consequently the magnetic field at La Chapelle goes on increasing.

When it reaches its normal value, which happens in a few moments, by the aid of the same commutator, the local circuit at La Chapelle is again separated from that of the line. When once the magnetic field exists it maintains itself spontaneously, for it moves the ring of the recipient, which determining, by means of the pulley, the movement of the exciter, maintains the field, which in turn maintains the movement of the recipient.

The two apparatus give each other the same mutual support as the piston and the slide valve of a steam engine.

The commutator therefore, serves only at each resumption of work. By an especial arrangement it allows the connection between the line and the local circuit at La Chapelle to be either made or broken gradually, and so as to avoid any heating of the wires. Four of the six coils forming the inducers of the recipient are introduced *in series* into the line, Creil-Paris, and then by means of the commutator they are successively withdrawn and re introduced *in quantity* into the circuit of the exciter.

The general problem, consisting in passing by a simple rotatory movement the elements of one circuit into another, whether these elements are in series or in quantity in both circuits, or in series in one of them and in quantity in the other, had been previously solved. (The reporter himself had given one solution.) But what is new and happy is to set up the movement first with the current of high tension, and then to maintain the magnetization with the current of the exciter.

Distribution of power at La Chapelle.—The power received at La Chapelle may naturally be measured with the brake. But when we did not wish to make single experiments it is employed totally or in greater part to move the pumps of the hydraulic accumulators at the station of La Chapelle. The surplus, when desired, is distributed among various instruments as below:—

1. An electric hammer of 80 kilos. in weight, with a fall of 0.80 metre, which works very well.
2. A lathe.
3. An electric windlass, which moves a small traveling crane for dealing with loads of 300 kilos.
4. An electric locomotive brake.

The distribution is effected by the most natural, and, perhaps, in the present state of science, the most practical procedure.

The axle of the recipient which already actuates, as it has been said above, its own exciter, actuates also mechanically another Gramme machine. This then becomes a generator, and effects work at the various recipients of the apparatus to be set in motion.

Among these recipients we must mention that which drives the lathe, since it has a double wrapping.

The double wrapping, first devised by M. Deprez to obtain a constant difference of potential at the extremities of a generating machine, has been subsequently applied by him to the recipients, where it secures a speed of movement which is approximately constant, in spite of the striking and sudden fluctuations in the resistance to be overcome.

The result is very well marked at La Chapelle. When the small recipient with double wrapping is in action it produces a force of 54 kilogrammetres per second or about two-thirds horse-power, and moves at the rate of 1,130 revolutions per minute. If the tool is suddenly removed so that it no longer meets with any resistance, its speed does not exceed 1,400 revolutions.

The first results ascertained by the commission.—Among the results hitherto acquired, the first to be pointed out is the continuity and perfect regularity of the movement of the machines, and in the almost entire absence of sparks at the brushes. There are incomparably fewer sparks in the generator and the recipient in spite of their high tensions and their large dimensions, than in the exciters which are at a low tension. This depends on the great power of the magnetic field and on the excellent proportion between the current of the rings and that of the inductors.

The brushes of the Deprez machines are adjusted with a slope of only 4° to 5° which is very advantageous as regards the yield.

No considerable heating is remarked in the machines, even after working for several hours.

The rate of movement is very moderate, about 200—220 turns per minute at the generator which answers to a peripheric velocity of 7½ metre per second, whilst in a Gramme machine making 1,000 to 1,200 turns per minute, the speed at the circumference was 12½ metres.

It has been possible to work as stated above since February as long as it has been desired, and if nine consecutive hours have not been exceeded this has been simply to avoid needlessly overfatiguing the workmen, such durations of action forming already a very satisfactory proof.

It may be that the recipient which has hitherto lasted without repairs may in turn come to require them. The rings will then be re-constructed as it has been done at Creil, and the working will be ensured for a long time.

Here we have results which, though easily verified and intelligible to all, are not the less fundamental, or, indeed, from a practical point of view, perhaps as essential as the yield itself, since the first demand of an industrialist is that his plant should be trustworthy.

I enter now a little more into the details of the experiments of the sub-committee.

(*To be continued.*)

CORRESPONDENCE.

NEW YORK AND VICINITY.

Lighting the Bartholdi Statue.—Subway Progress.—Incandescent Lighting in the Up-town Districts.—Proposed Electric Railway at Elizabeth, N. J.—The Westinghouse Electric Lighting Station at Plainfield, N. J.—Secondary Batteries Tried on the Eighth Avenue Railroad.—Legal Struggle over Secondary Batteries.—Electric Lights in Harlem.—Laying Submarine Cables for the U. S. Signal Service.

THE peculiarities of official red tape have been brought conspicuously before the public in connection with the custody of the statue of Liberty. Its importance as a light-house or beacon has been repeatedly spoken of by the press, and the question of illuminating the statue so that it would stand out like a pillar of fire, has received considerable attention from experts in lighting, as well as many amateurs who have communicated their ideas to the daily newspapers. The attempt to throw beams of light upward, while effective so far as the pedestal is concerned, did not bring the statue into view on account of its darker color. It is very doubtful whether this can be done by electric lamps; but it is possible. If the statue were treated to a coat of luminous paint it might be rendered visible at a comparatively small expense, especially if some of our enterprising paint dealers should offer to furnish the necessary material as a patriotic contribution to the cause. It would be a relief if something could be done to dispose of the subject, which is growing wearisome.

The subway commissioners promise to close the season with a vigorous demonstration of their power to enforce the underground enactments. As the work of constructing an asphaltum conduit cannot be pushed with sufficient rapidity, three differently located routes have been selected in which iron pipe will be used embedded in hydraulic cement. Perhaps even greater progress might have been made, had the various companies possessing the necessary franchises been allowed to proceed. An attempt in this direction was made by William H. Johnstone, representing the New York Underground Telegraph Co., but before he could make a hole in the ground he was captured by the police.

The establishment of an up-town central station for incandescent lighting by the Edison company is being delayed, by reason of the requirement that the conductors shall be included in the general subway plan. Many new houses are being wired in anticipation of the future introduction of house-to-house lighting.

Among other proposed electric railway schemes is one at Elizabeth, N. J., in which the line is to begin at Elizabethport and run to the Union depot *via* East Jersey street, thence through East Broad street and Jefferson avenue to North Park, at the North Elizabeth station on the Pennsylvania railroad. Whether the plan will materialize is a question of some doubt.

The new Westinghouse central station system at Plainfield, N. J., is expected to be ready for operation very shortly. As it will be the first practical application in this vicinity of electrical distribution by secondary currents, the operation of the plant will doubtless attract much attention from all who are interested in incandescent lighting.

The trial of a car driven by secondary batteries on the Eighth avenue street railway, has awakened renewed interest in the practicability of accumulators. Experimenting is going on constantly, looking to the successful cultivation of this branch of the electrical field. There are indications also of a legal struggle over

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the patents, as may be inferred from the following card which has appeared in the daily press :

STORAGE BATTERIES AND IMPENDING LITIGATION.

On May 17, 1882, the public was cautioned against making investments in any scheme or venture based upon the claims of one Camille Alphonse Faure, relating to secondary or storage batteries or accumulators, and notice was then given that the Brush Electric Co., of Cleveland, were the rightful owners in this country of the inventions laid claim to by Faure and others and were enforcing their rights by proceedings before the proper tribunals of this government. Those proceedings have been pushed with diligence by the Brush people, and have been opposed and delayed in every possible way by the Faure interests and others for a period of four years. Decisions, however, have at last been rendered in favor of the Brush interest and patents have been granted to it covering the entire ground claimed by the Faure people, and the Faure patent is thus rendered valueless. 27 patents, covering the field above referred to and of cognate scope, have been granted to the Brush Electric Co., and one or more of them cover all the commercial batteries that have been up to now devised. The two principal and foundation patents, which control the use of the so-called Faure storage battery, as well as the Sellon-Volckmar battery and others in this country, and supersede the patent issued to Faure, Jan. 3, 1882, numbered 252,002, are dated and numbered respectively March 2, 1886, No. 337,298, and March 2, 1886, No. 337,299.

The public are again advised, as they were in 1882, of the rights of the Brush Electric Co., and that these rights will be enforced.

Particulars may be learned of the undersigned, or of William C. Witter, Esq., or William H. Kenyon, Esq., their counsel, 32 Park Place, New York.

BRUSH ELECTRIC CO., Cleveland, O.

The Harlem Electric Light Co. has requested permission from the board of aldermen to light 125th street, between Fourth and Ninth avenues at its own expense for 90 days, subject to the approval of the subway commission. This offer to do something for nothing appears to have temporarily paralyzed the board, and action was deferred until the next meeting, to afford an opportunity to investigate such an unusual offer.

The F. M. Ricketts Co., of this city, laid a government cable for the signal service, on November 17, between Block Island, R. I., and the main land. The cable was brought from England on the steamer *Ludgate Hill*, and was transferred at Brooklyn to the barge *Bella*, which sailed on November 11th, in charge of F. M. Ricketts, and towed by the ocean tug *E. Luckenbach*. Capt. M. W. Goodyear, from the house of E. S. Greeley & Co., accompanied the expedition, and his presence was sufficient to drive away all fear of a monotonous voyage. Upon returning to New York and taking in supplies, Mr. Ricketts will go south at once to lay a second cable for the same service between Cape Charles and Cape Henry.

NEW YORK, November 19th, 1886.

PHILADELPHIA.

Electric and Cable Railways.—The Electric Pneumatic Company.—The Electrical Department of the City of Philadelphia.

THE Philadelphia Traction Company operate a majority of the street railways of this city, and use the cable motor on some of them, and although the motor is quite a success, the officials of the company are constantly on the look-out for some newer and better motive power and with this object in view president Widener recently visited New York. He says :

"I recently went over to New York and rode in an electric motor car, the movement of which pleased me, and I was so favorably impressed that our company propose to experiment with it in this city as soon as a car now being built to suit our roads is finished. The electric-motor power is stored in the car itself, and will run the cars ; that much we know. The only question remaining is as to the cost of maintenance of the cars and the furnishing of the motive power. We will put the first car on the Chestnut street line, and if the experiment justifies the change we will, of course, adopt the new motor for that line and probably for others of our system."

City councils, on July 8, passed an ordinance permitting the Electric Pneumatic Company to lay tubes in certain streets of this city, allowing thereby the introduction of a new system of transmission of packages and messages calculated to revolutionize the present messenger and local telegraph service. The system differs from that of the ordinary pneumatic tube system practically in only one particular. Instead of a single tube stretching from a given point to a certain destination, a main tube is laid along certain streets from which any number of connecting tubes branch off. By an ingenious method of switches, operated by electricity from the main office, a conical carrier containing a message or parcel traversing the main tube will find its way suddenly blocked and will be turned into a side tube by means of a switch, much as a street car is turned from one street into another by means of an intercepting bar. In this side tube switches will also be thrown up, guiding the carrier into any designated house or store. The company intend placing the tubes —or "terminals," as they call them—in such stores and houses as will bring them trade. At each main station messengers will be kept to deliver messages to houses and stores where there is no connection. The stations are to be so placed about town that in no case will a boy be compelled to go more than three blocks from his office to deliver a message. There is to be no charge for rent, as in the case of the telephone, but stamps will be used to be canceled in the district station as each package comes in, so that only each service need be paid for.

In addition to the system of messenger tubes, another known as "package tubes" will be put in operation after awhile. The messenger tubes have a diameter of two and one-half inches. The diameter of the package tubes will be from eighteen to twenty-four inches. The latter system will not be extended to the household service, however, and the packages will be delivered from the district stations by messenger. There will be no charge except for actual use, and the tubes will be placed in every house and store where there is likely to be any use for them. No schedule of prices has as yet been made, but the general rule has been laid down that it will be uniform for all districts outside the one where the sender is situated, at about half the rates now charged. The system of waiting for a messenger boy will be entirely obviated, for each person can drop his parcel in the tube, which will take the place of the call bell, and before a boy could start to answer a summons the package will not only have reached the station but be on its way along a street tube.

An ingenious arrangement has also been contrived by which a carrier may be sent into a patrol-box, and by means of the escaping air made to blow a whistle, and thus call a patrolman in case of fire or need of police assistance. A red carrier will tell that a certain house in the district is on fire, and a blue carrier will call for police assistance. All the householder need do is to drop one or the other carrier into the tube, and forthwith the whistle will call the patrolman to the box.

The invention is that of Henry Clay, of this city, originator of Clay's telephone. John C. Scott, of John Scott & Son, coal shippers, is president of the company. The streets through which tubes will be laid are Walnut, from the Delaware to Tenth ; Fifteenth, from Carpenter to Fairmount avenue ; Market, from Fifteenth to the Schuylkill ; Front, from Spruce to Callowhill, and Fourth, from Spruce to Library. The main office will be at 422 Library street, where a constant stream of air will be sent through the pressure tube, and a vacuum created in the vacuum tube by a patent pump instead of by a monster fan, as is the custom with pneumatic tubes at present.

The quarters of the electrical department of the city in the new City Hall are now nearly ready for occupancy, and a visit to them shows them to be very complete, not only in added convenience for the employés, but in the magnificent outfit of electrical apparatus. The rooms are spacious and well lighted, and the collection of instruments is believed to be one of the most complete in the world. The rooms, three in number, are on the fifth and sixth floors, on the Juniper street side of the building, immediately opposite Market street. In these rooms are situated the police signals and telegraphs, the fire alarm, repeating and recording instruments, the switch-boards and the batteries.

The telegraph service of the city includes the fire-alarm service, the telegraph and telephone service of the police department from each police station and patrol box, the House of Correction and the ambulance service. The wires from all these various services concentrate in these rooms. These wires will be collected together at the telegraph pole at the corner of Cuthbert and Juniper streets, where they will enter two cable boxes and be connected to the separate wires of numerous lead-covered cables. The cables used are those of the Underground Cable Company of Pittsburg. At the foot of the pole the cables enter a simple wooden conduit, divided into numerous sections, which conduct them to an iron conduit reaching from the corner of Juniper and Filbert streets to the north-east corner of the new public buildings. At the corner of the pavement this iron pipe debouches into a tunnel extending from that point to the cellars of the building. In this tunnel the cables will be supported on shelving, and from it the cables are led in a brick conduit to the corner of the north-east tower. In the angle of the tower and back of the hanging stair-case, which will ultimately occupy it, is a triangular space, up which the cables will be led to the floor of the fifth story. An iron ladder attached to the wall will allow access to the cables for repairs and additions in this position. Between the ceiling of the fourth floor and the flooring of the fifth a cable box, built of wood and whose bottom is made of plate glass, will carry the cables to the rooms of the electrical department. During this entire course the most scrupulous care will be used to maintain perfect insulation and to avoid the effects of induction.

On entering the room of the chief the visitor is struck by its spaciousness and general beauty and by the extremely handsome collection of instruments. On the west side of the room is a beautifully carved switch-board of solid mahogany. The céntre of the room is occupied by two large tables on which are placed the various repeating, recording and telegraph instruments, each enclosed in its box of beveled plate glass and glittering with polished and engraved brass and nickel. On the south wall are the

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signal bells of the various circuits and two signal telegraph instruments. Near the window is the temporary telephone switchboard, together with the telephones and receivers.

Each station house in the city is provided with telegraphic communication with the central office. The wire from each station, on reaching the central office, runs to a signal bell and thence to an ordinary telegraph relay and key. By this means all important information is supplied at once to the central station, and in case of need, information and orders can be sent at once to other police stations.

The ordinary telegraph repeater is now in use, and requires, of course, a regular telegraph operator. Another system is being introduced, which will avoid many of the difficulties connected with that system. This is a return to a much improved form of the old Wheatstone dial telegraph. A dial, whose face bears on its circumference the letters and numerals, together with the word "Fire," has supported over it a single needle. On the outside of the dial and opposite each letter or figure is an ivory push button. It is intended to arrange one of these at each end of the line. Upon one of the buttons being pressed, the needle of the second dial will move to the corresponding letter. By this means the messages are kept secret. No one but the receiver can possibly learn the message. The ordinary form of sounder has the disadvantage of being easily understood by any one within earshot who understands telegraphy, and the printing telegraph leaves a record which is liable to be read.

The Gamewell system of fire alarms, now in use in this city, includes a large number of patents, the whole object of which is to render an alarm of fire perfectly distinctive, accurate as to location, and as certain as human ingenuity can make it. All sorts of emergencies and accidents are provided for, lest a failure at a critical moment should lead to serious error or great calamity.

The handsomest part of the outfit of the electrical department is the switch-board, which stands on the western side of the main operating room. It is of solid mahogany, elaborately carved and decorated, with two heavy pillars of mahogany, one on either side. At the top is a series of annunciators, which indicate by dropping a shutter covering the numbers on which circuit the signal originated. Below these is an elaborate system of switches directing the current into some one of several directions.

Generally in cases of fire the message is sent out over all the different wires by the automatic repeating apparatus. The object of this apparatus is practically to turn the single message into twenty or more simultaneous messages, each of which is directed to a fire engine house. The impulses, as they arrive from the switch-board, detach a lever which allows a commutator to revolve by clock work. The commutator is a cylinder of insulating material, on which is set in regular order strips of german silver to the number required. Against the cylinder rests a series of springs corresponding to the number of strips.

Each impulse allows the commutator to make one revolution, and during that time, each spring comes for a brief period in contact with a silver strip. The messages are not sent out exactly simultaneously, since the strips are not set on one horizontal line, but before the spring of the first circuit leaves its strip the second spring has made connection with the second strip. As a result, less battery power and less injurious sparking takes place. When the commutator is at rest all the springs rest on an insulating surface of the cylinder. The strips and springs each make a portion of an electrical circuit, which is only closed when they are in contact. The other end of each circuit is in an engine house, and the result of the impulse is to ring an electric gong and make a record at the house. The number of revolutions of the commutator, and, consequently, the number of impulses sent out depends upon the number received, and thus in the supposed case mentioned every engine gong in the city would ring first five, then two and then eight times. This signal is repeated five times in order that no doubt may arise as to the number of the call. As a table giving the location of each box is beneath the gong in every house, the neighborhood of the fire is at once indicated.

It is designed that the telephone service of the police, which is now introduced all over the city, shall have its central station in these rooms in time. At present the police central telephone station is at the engine house on Race street, below Broad, and only a small switch-board connected with all the engine houses is in the electrical rooms. It does not differ materially from the telephone switches now familiar to those interested in such matters elsewhere.

The electrical department of the city is under the direction of chief D. R. Walker, under whose general direction the rooms have been fitted up. The actual work has been done under the personal supervision of his assistant, Mr. John C. Sager, who has himself made all the multitudinous connections of the wires of the various circuits, upon whose proper adjustment depends the efficiency of the entire system.

PHILADELPHIA, November 18th, 1886.

BOSTON.

Meeting of the Society of Arts.—Electric Lighting in Boston and Vicinity.—Electric Police Signals in South Boston.—Underground Wire Construction.—The Cincinnati Decision in the Government Telephone Suit.—American Bell Telephone Co.'s Stock.—New England Telephone Co.'s Quarterly Report.—The Erie Telephone Co.—The Providence Telephone Co.

THE regular meeting of the Society of Arts was held on the evening of the 13th inst., at the Institute of Technology. Prof. Chas. R. Cross presided in absence of president Walker. Messrs. Frank Ridlon, C. D. Jameson, H. E. H. Clifford and D. P. Bartlett, were elected members. Prof. Cross, after explaining in a few words the high and low tension systems of electric lighting, introduced Mr. Ridlon, of the Brush-Swan Electric Lighting Co., who read a technical paper on "Incandescent Electric Lighting from an Arc Light Circuit."

The subject of electric lighting seems to occupy attention more and more, as the business situation grows better. The city officials of Providence, Worcester and Lynn, visited and inspected the Salem electric street lighting works, on the evening of the 11th inst.

The Suburban Electric Light and Power Co. has been formed for the purpose of supplying light and power in Allston and Brighton. Dr. Robert Amory is president of the company. The station will be at the Brookline Gas Co.'s works.

Sealed proposals were opened at the office of the lamp department, City Hall, Boston, at 12 M. on the 14th inst. for furnishing electric lights for public street lighting for a period of three years from the date of contract. Each lamp will be required to burn every night in the year from sunset to sunrise, or during 3,828 hours, according to a time schedule furnished by the superintendent of lamps. The competing companies are the Charlestown Gas Co., the Weston Illuminating Co., the Citizen's Electric Light Co., the Brush Electric Light Co., and the Merchant's Electric Light and Power Co., each of whom offer to furnish the required light at 65 cents per lamp, per night. The last-named company also offers to supply 100 to 300 lights for 55 cents per lamp. The bids are taken under consideration.

On the evening of the 11th inst., the Cambridge Electric Light Co., gave a public reception and banquet at the central lighting station, 23 Main street, Cambridgeport, which was attended by a large number of residents. Supper was served in the upper hall and was attended by upwards of 200 persons, Mr. E. H. Milliken, presiding. After the banquet, speech making was indulged in for a short time. The Cambridge city government was present in a body.

For the second time, an attempt has been made to demolish a police signal box in South Boston; by means of paving stones the door of one of the boxes was broken. Although the "toughs" of this section are constantly giving their testimony to the efficiency of the police signal, yet, the authorities have not adopted or extended it.

The aldermen of Lynn having granted the necessary permission, the Woodward Underground Telephone & Telegraph Co. will immediately begin laying its cables in Munroe, Washington and Boston streets to the Peabody line, and through Boston street to the Saugus line, intersecting the Washington street line. The telephone and telegraph company in Lynn probably will avail itself early of the advantages of the Woodward system. The Boston connection will intersect at Franklin street, running through Western avenue to the Saugus line.

The New England Telephone & Telegraph Co., are busy putting down their wooden conduit through Tremont and side streets. A trench is dug about four feet in depth; the boxes are of plank with cross intersections, to form rows of tubes, in number, four one way and three the other, making 12 tubes; the sections are about 10 feet in length and are well tarred before laying Brick man-holes are constructed at intervals.

The Edison Electric Light Co. have been laying their tubes along the curbstones in several streets.

Underground conduits have come, and to stay, but in a shape somewhat disappointing to the proprietors of numerous "systems" who have been waiting to be called upon. This is a severely practical world, after all, when it has its eyes open it don't fail to avoid the impracticable.

The event of the month in telephone circles has been the decision in the case of the United States *vs.* the American Bell Telephone Co. at Cincinnati. The decision was read by Justice Sage, who said that it was the unanimous decision of the bench, *i. e.*, Justices Jackson, Sage and Walker. The decision is in effect, that the United States have no jurisdiction on the American Bell Telephone Co. in Ohio, or in any other state where the same facts exist, but only in Massachusetts where the company is chartered. This is of course regarded as a great victory by the telephone people, and adds another to the long list of legal conquests by them. Some day, I hope to see the history of the legal department of the Bell company made known, in order that the great skill and ability of its moving spirit, Mr. J. J. Storrow, may be

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made known; no one will ever know it from Mr. Storrow's modest lips.

The stock of the Bell company rose from about 206 to 215 on receipt of the news. In the old speculative times, it would have risen at least 50 points—but now even Mercury has leaden wings.

The directors of the New England Telephone and Telegraph Co. met on the 27th of September, and declared a dividend of 75 cents per share (¾ of one per cent.), payable November 15 to stockholders of record October 30. Transfer books will close November 1, and will reopen November 13. The following is the statement of business for the quarter ended September 30:

Quarter ended Sept. 30.—	1886.	1885.	Increase
Gross receipts	$232,585	$236,520	*$3,935
Gross expenses	162,774	176,654	*13,880
Net earnings	$69,811	$59,866	$9,945
Construction	778	20,649	*19,871
Balance	$69,033	$39,217	$29,816
Jan. 1 to Sept. 30—			
Gross receipts	$681,372	$699,479	*$18,107
Gross expenses	488,469	501,023	*12,554
Net earnings	$192,903	$198,456	*$5,553
Construction	2,847	67,002	*64,155
Balance	$190,056	$131,454	$58,602

*Decrease.

Compared with the previous quarter, ended June 30, the showing is quite favorable, gross earnings increasing $4,542, and net earnings $10,626, while the balance is $11,018 larger.

The Erie Telephone Co. took a little spurt in sympathy with the Bell stock, but it soon appeared that nearly the whole stock was for sale, and consequently it sharply declined. There has been newspaper talk that the Erie company have perpetual rights to territory, which other folks say has not as yet been given them, something after the idea of the "apostolic succession." This reminds one of the remark of the fox to the chickens "How do you prefer to be eaten?" "We don't want to be eaten at all." "My friends," says the fox "you are departing from the question."

The Providence Telephone Co. have secured their permanent contract with the "old parent" whom it loves so well, on the "usual terms" as suggested in my last.

BOSTON, November 16, 1886.

CHICAGO.

Reported Discovery of Copper Ore in Illinois.—The Strike in Chicago.—Fires and Electric Light Wires.

SOME three years since in sinking a well on a farm near Rochelle, in Ogle county, Illinois, the workmen claimed that at the depth of about 20 feet from the surface, they had gone through a vein of copper ore. Nothing, however, was done in the matter until the latter part of October last, when the proprietor of the land had a conference with an expert miner named McHenry, who found a considerable quantity of drift ore on the farm, and it was finally arranged to sink a shaft close to the well. The work is now being pushed rapidly, and the expert claims that the indications are excellent for a vein of good ore from 17 to 19 inches thick, immediately below the sand-stone layer in which the drills now are.

Should the result pan out in accordance with his opinion, another industry will be added to the wealth producing interests of the state, and it is by no means impossible that extensive copper wire works may be erected here or at the mine.

It is proper to remark, just here, that in case the whole thing on being investigated, gives a better showing of "salt" than of copper, the wire drawing project will be abandoned.

Chicago has gone through one more labor strike. The poor dupes believed—they had been taught to believe, that the necessary power to play the despot had accumulated, and that the appointed time to bring proud capital to its feet was now.

They came—they saw—they failed. It is sad to witness the periodical struggle—depressing to think of the misery which a few arrogant and designing leaders can and do produce when a strike is ordered. Were there no innocent sufferers, who, for the time being are virtually deprived of father, husband or brother, shivering with the cold, powerless to combat its chief ally—hunger—compelled by the laws of an organization in which they have no voice, to suffer, that an impossibility may be accomplished—were it not for these, the situation might be a less pitiable one, for the bread-winner alone would be the sufferer.

The history of these unfortunate combinations, has nearly always been repeated with each fresh demonstration. There are those still living who remember the first telegraphers' strike. They were confident of their ability to coerce their employers. At that time the operators were receiving large pay for the service rendered, and were looked upon, as a class, as members of a profession, rather than as journeymen who worked at a trade.

The result is well known. The organization went to the wall and many a mother and child knew to her cost the sequel of a strike.

Again the organization on a better foundation, as it was said, was quietly introduced into the various central offices, thence spreading locally, until, all understandings to the contrary, notwithstanding, the members of the brotherhood found suddenly that they were banded together for a strike. Few of the old time veterans were found on the rolls, and the honest fellows of the organization holding honor next to honesty, struck when they were bidden, and again there was weeping and wailing. Worse—for this time the female operators were drawn into the arena, and joined the malcontents. We all know the conclusion of this fiasco.

As with this class, so it was with the telephone employés. The history of the strike is the same, with slight variations, everywhere, and the sooner the employed accept the facts:

1st. That an organization which places good and poor workmen on the same basis of pay, and proposes to compel the paymaster to accede to its wishes, is always productive of mischief and misery; and

2d, That capital never suffers from cold or hunger; the better it will be for the worthy man who earns his bread by the sweat of his brow.

There is always in the human mind a desire to explore a mystery—sometimes there is human pride in ventilating an opinion, and occasionally it is necessary to cover a fault or a lapse of duty, to escape blame. When a fire occurs in a building where there are electric wires, it is not unnatural or unusual for the cause of the conflagration, if this is not at once apparent, to be sought first in the direction of an electrical origin, and the electric light man should be prepared at all times, by having his lines in proper order. What induces these remarks is a case of recent occurrence, where a mysterious fire occurred, and there seemed at first no other possible cause but the electric light current to which to attribute it.

The fire occurred at an early hour in the morning, but it was one of the slow, creeping kind, and might easily have been eating its way into prominence since the shutting down of the circuit at midnight. But a careful inspection of the premises showed that there was good insulation the entire length of the wire, the place was too dry to admit of a suspicion of dangerous dampness, and the wire was intact in the neighborhood of the spot where the fire originated.

Had the blaze started three feet away in the direction of the wires which were run along the joists at least 14 or 16 inches apart, these would have been burned off, and electric lighting would have received a black eye at the fist of public opinion.

There is a moral here. Place the lines well away from accidental contacts, test regularly for insulation, and keep the first ground off. So shall electric light men have peace, and be honored in the land.

CHICAGO, November 16, 1886.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICIAN AND ELECTRICAL ENGINEER, 115 *Nassau Street, New York city.*

[62]—The November issue of THE ELECTRICIAN AND ELECTRICAL ENGINEER contains an article on "Proportioning Conductors in Electric Distribution," by Wm. S. Turner. Should not the paragraph just before the last formula read "a circuit of 40 Westinghouse lamps, 100 volts .6 *ampere* each," instead of "6 amperes?"

Yours truly, OSBORN P. LOOMIS.

Lynn, Mass.

[Our correspondent is correct; it should read .6 ampere. Error in proof-reading.—ED.]

CATALOGUES AND PAMPHLETS RECEIVED.

We have received from the Eastern Electric Cable Co., Boston, a set of circulars and price lists setting forth a great variety of insulated wires and cables manufactured by them, accompanied by testimonials of a high character as to the excellence of their india-rubber insulation. It is interesting to note the establishment of the manufacture of their wire and cables in England, by the Clark Electric Insulating Co., Limited, London.

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ELECTRICAL NEWS AND NOTES.

CIRCULAR OF THE EDISON ELECTRIC LIGHT CO. ON THE LEGAL AND COMMERCIAL STATUS OF INCANDESCENT LIGHTING.

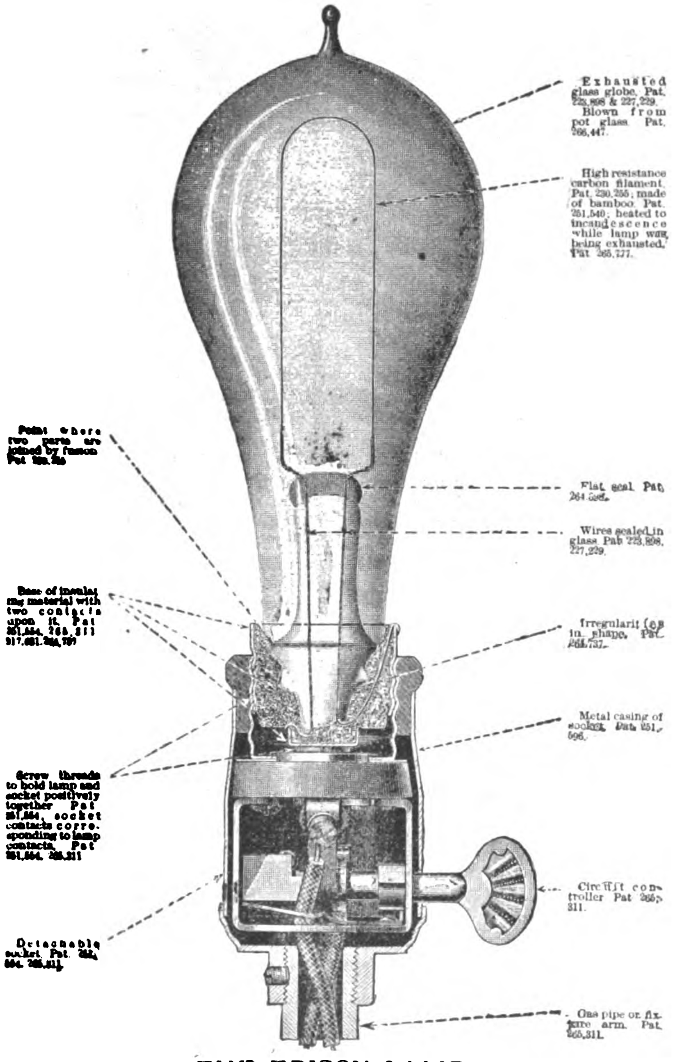
EXECUTIVE OFFICES THE EDISON ELECTRIC LIGHT CO., 16 AND 18 BROAD STREET.

NEW YORK, October 7th, 1886.

To whom it may concern:

Your attention is respectfully solicited to the following facts. They are submitted not in a spirit of menace or as a threat, but simply as a matter of abstract justice both to shareholders, whom we represent, and to yourselves, as parties to whom our true position has been persistently misrepresented.

The fact that Mr. Thomas A. Edison invented the incandescent lamp in the form in which it is now presented by all electric light companies was so widely proclaimed by the publication thereof in every class of literature at the time of the invention, that it would now seem very like an insult to the intelligence of the community to recall it. Indeed, a retrospective view of the history of the great invention is rendered unnecessary by the fact that even the infringing companies themselves do not dwell upon their claim to the ownership of original patents, but *fortify their position by the assertion that Edison's patents are invalid* and open to the public, and offer in corroboration of their statement the apparent apathy of the Edison company in the matter of defending them. That they, or doubtless many of them, are honest in their belief, and therefore in their representations, may be conceded without prejudice to the facts. In this way alone can be explained the business policy pursued by them of risking large private fortunes as well as the property of the shareholders of their respective companies in the form of guarantees against any damages the Edison company may ultimately obtain from them or their customers for infringement of its patents.

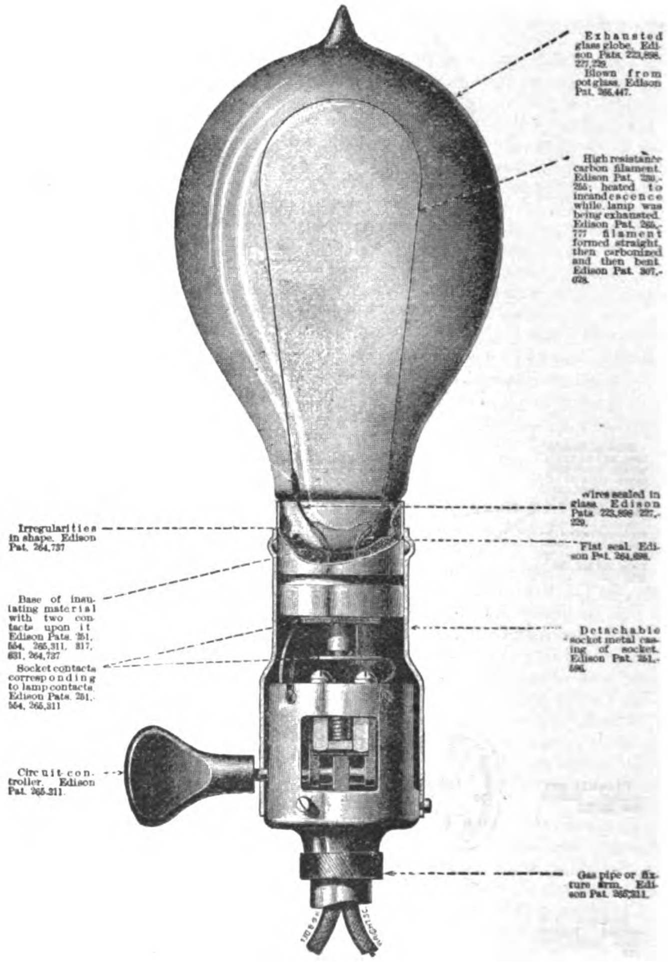


THE EDISON LAMP

It may very properly be asked does not the lapse of several years without the Edison suits appearing in the open courts confirm the charge of apathy and prove the claim of invalidity. The Edison company answers NO. They had reasons which restrained them from active patent litigation at the start, but that activity was ordered over a year ago, and in consequence of it more than 100 suits are now pending. Many of these, necessarily the most important thereof, will, in the natural order of legal procedure, reach trial within the coming year. Quiet preparation, together with important work done abroad, will ensure the rapid progress of these suits through the courts the coming winter, and, to the end that no false steps shall be taken, additional counsel of the highest ability have lately been retained by the Edison company.

Understanding that you are using, or are contemplating using, incandescent electric light based upon Mr. Edison's inventions, and in conformity with the spirit and essence of the above, your attention is called to the following statement showing what are the patents owned by the Edison company.

We present also in the enclosed folder[1] statistics showing the extent of the business done by the Edison company under these patents. In contrast with the detailed statement therein submitted, we need only state that carefully compiled statistics, show that the 15 infringing companies, aspiring to secure business, by



The United States Co. (Weston Lamp) Infringing the Edison Patents.

the illegal use of our patents, had up to the 1st day of October, 1886, placed in central stations and isolated plants throughout the U. S., a total of only 84,600 lamps. This includes a great number of lights now discontinued, and also several thousand lights yet to be supplied from central stations which were at that date in process of construction.

We are legally advised that we may look to you for damages in case we maintain any one of the broad patents enumerated herein. The measure of damages for infringement of patented goods has been fixed by the courts at about three times the loss sustained by the owners thereof. The extent of the damage to the Edison company may, in a degree, be approximated by a retrospective glance at the number and formidable character of the companies now embarked in the business of electric lighting, and therefore directly detracting from profits legally the right of the Edison company.

For the purpose of enabling you to estimate your liability in

1. The folder shows a list aggregating 331,363 lamps.

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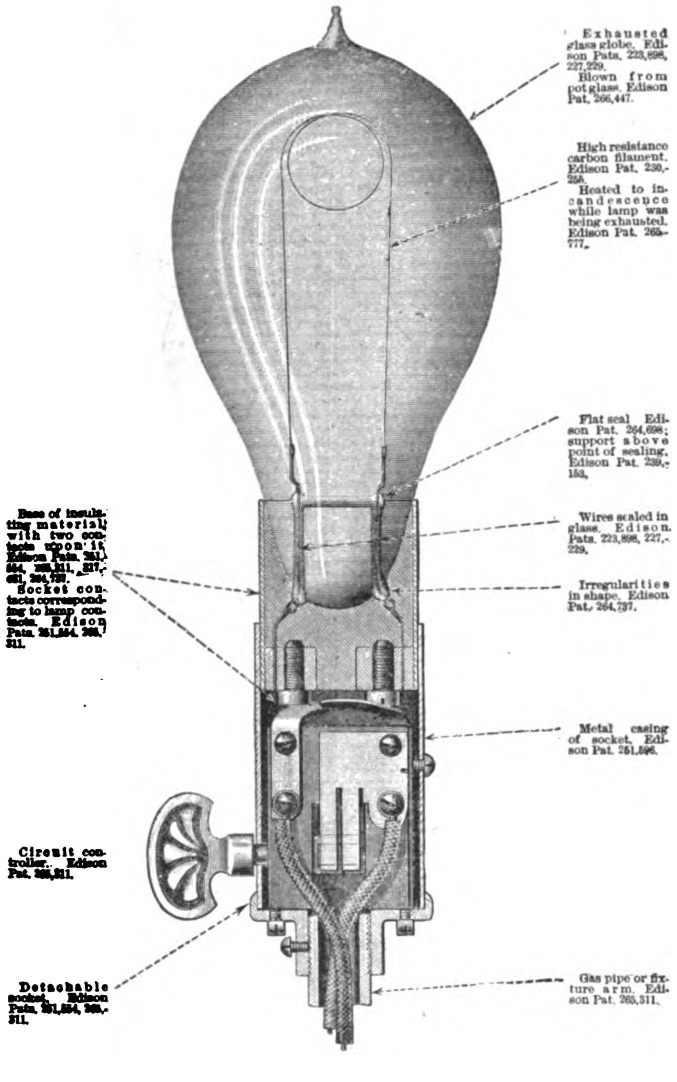
the event of the Edison patents being sustained, we may state that a conservative calculation apportions a damage of $25 for each lamp in an original installation, and $2.50 for each renewal lamp, independent of the fact that such decision would necessarily render your plant inoperative.

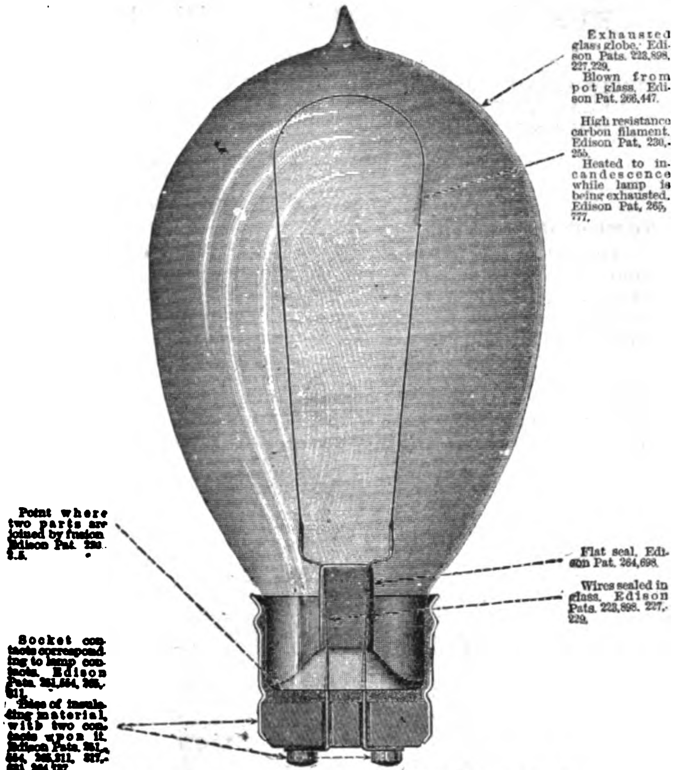
As to the probability of such decision, you are reminded of the well established fact of the origin of the incandescent lamp, of the furore created at the time by the announcement of its discovery, and of the pilgrimage of thousands to Menlo Park to witness the exhibition made by Mr. Edison. You are further reminded of the fact that the Edison patents have been fully sustained in Germany and in England, in both of which countries a most exhaustive search utterly failed to develop either a lack of novelty or a structural weakness in the patent itself,—the two great rocks upon which most inventors' ships are stranded. You are further reminded of the fact that the delay in reaching a decision does not impair its force when attained, a notable example of which is the Goodyear Rubber Co., whose suits were not *finally settled until after the expiration of the patents*, when large amounts of money were collected in damages.



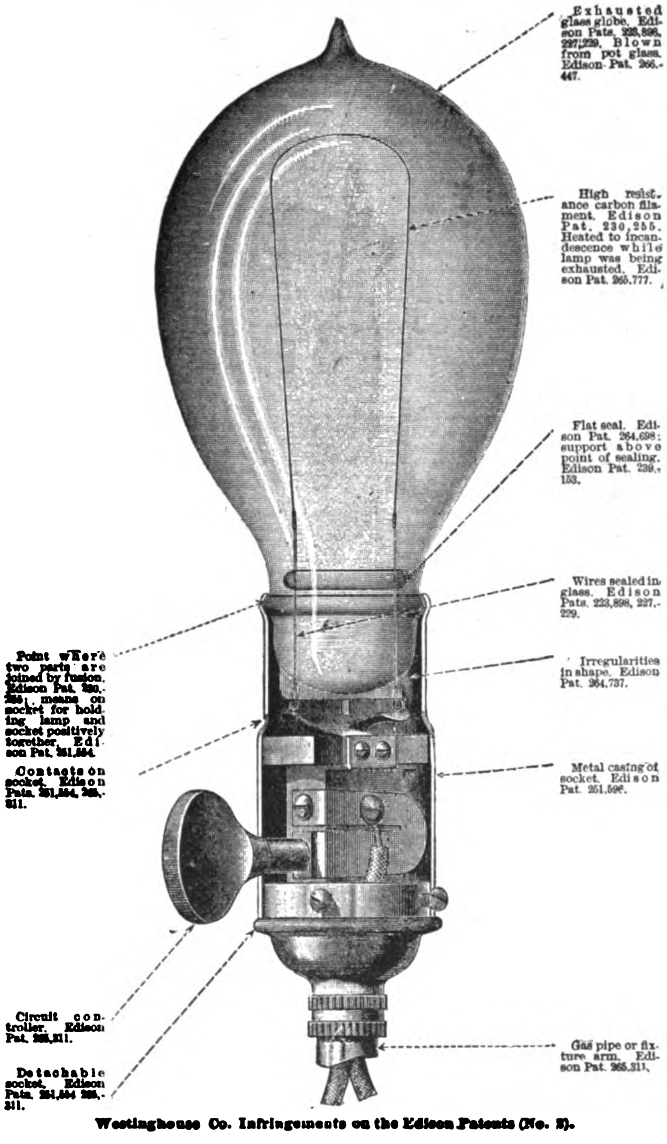
Brush-Swan Infringements of the Edison Patents.

In respect to the value of the guarantees so freely given you by the companies themselves and by private individuals interested therein, we would respectfully inquire whether in your judgment either the corporations themselves or the individuals interested therein would be able to protect you from the avalanche of damages that the very multiplication of their business transactions during a long continued period of immunity would bring about them? In point of fact, does it not go without saying that the greater the extent to which they may exploit their business, the more disastrous will be the weakness of their guarantees when the day of settlement comes?

In respect to the patent suits brought against the Edison company, attention is called to the imperative necessity the opposing companies were under to do something to break the moral force of the fact of the Edison suits—to the minor and even trifling details involved and generally to the fact that whilst the Edison patents cover broadly the fundamental principles of incandescent



Westinghouse Co. Infringements of the Edison Patents (No. 1).



Westinghouse Co. Infringements on the Edison Patents (No. 2).

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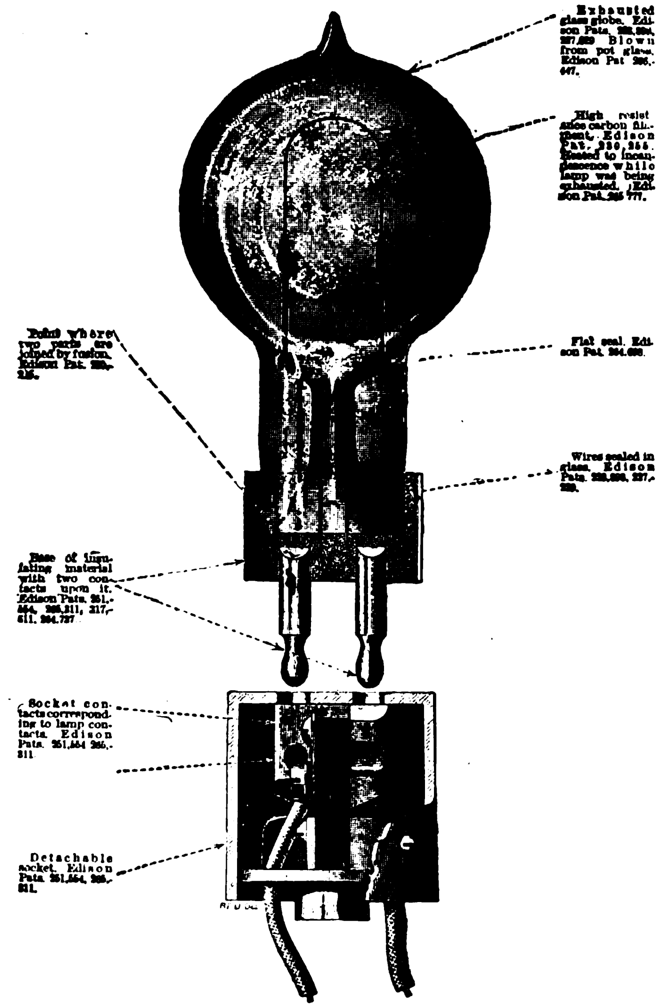
lighting, the Edison company does not pretend that the experience of others will not suggest to them more or less of improvement in detail. You are simply reminded in this respect that the Edison company being the first in the field, and their work being upon such an extensive scale, they have necessarily had the larger experience, and consequently their detail must possess the dual quality of originality and superior fitness. But, be this as it may, no detail patent has the force to either mulct a user in damages or stop his plant.

Trusting that our presentation of this purely business matter in a business way and in a spirit the reverse of hostile, may fully accord with your sense of justice and fair dealing, we beg to remain,

Very respectfully,
THE EDISON ELECTRIC LIGHT COMPANY,
E. H. JOHNSON, *President*.

DESCRIPTION OF THE EDISON LAMP.

The Edison incandescent electric lamp consists of a chamber or receiver made entirely of glass, from which the air has been exhausted as completely as possible. This chamber is composed of two parts, a bulb or globe and an inner stem or tube; these parts are united by the fusing together of the glass. Through



Bernstein Infringements of the Edison Patents.

the inner stem pass two wires, and to the ends of these wires within the globe are attached the ends of the incandescent conductor. This is a filament of carbon of high electrical resistance. The ends of the filament are connected to the wires by electroplating the joints with copper. The portion of each wire which passes through the end of the stem is of platinum, and at this part the glass is melted around the wires and the stem is pressed down upon them so as to form a flat seal. The lamp globe has at its lower end a base composed of plaster-of-paris upon which are secured two contact-plates, one of which is a screw-threaded ring encircling the base, and the other a tip or button at the extremity of the base. Each of the two wires leading from the carbon filament is connected to one of these contacts.

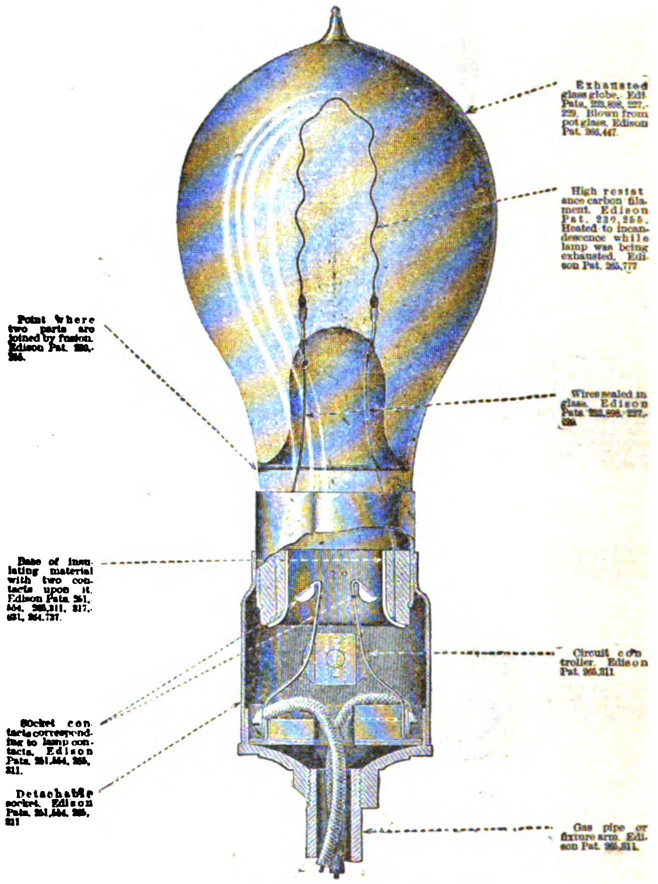
The lower end of the globe is irregular in shape, that is, it has projections extending from it into the plaster. This prevents the lamp from turning in its base.

In making the lamp the globe is first blown from the molten or pot glass; the wires are laid in the stem or tube, the end of the stem is pressed down upon them and the carbon filament is attached to them. This filament is made from a thin strip of bamboo fibre which is bent into the form of an arch or loop and then carbonized. The globe is then secured by fusion to the stem which has an enlargement or shoulder for this purpose. The lamp is then exhausted of air from the top of the globe, and sealed by fusing the glass together at that point.

While the lamp is being exhausted a current of electricity is passed through the filament, which heats it, and thus drives out the air and other gases which are contained in the pores of the carbon. After the lamp is sealed the base and contact-plates are placed upon it.

For each lamp is provided a socket or holder, so arranged that the lamp can be readily placed in or removed from it; it has within it two contact-plates placed so as to correspond with the contact-plates on the base of the lamp. The socket is adapted to be placed upon a fixture or any other suitable support, and the wires which are to convey current to the lamp enter the socket, and are connected with the contact-plates within it, so that when the lamp is placed in the socket the electrical circuit is completed to and from the carbon filament. The socket is provided with a key or circuit-controller, by turning which one side of the circuit is broken or closed, whereby the lamp is extinguished or lighted.

The following is a statement of certain of the patents owned by The Edison Electric Light Company, the features included in which are employed in the manufacture of the Edison lamp as



Mather Co. Infringements on the Edison Patents.

described above and as shown in the cut, figure 1, and also in lamps made by other manufacturers of incandescent electric lamps as shown in the other cuts:

1. Patent No. 223,898, dated January 27th, 1880, is for

"1. An electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance secured to metallic wires.

"2. The combination of carbon filaments with a receiver made entirely of glass, and conductors passing through the glass, and from which receiver the air is exhausted."

2. Patent No. 227,229, dated May 4, 1880, is for

"In an electric lamp, the combination with a hermetically sealed vacuum chamber made entirely of glass, of metallic conductors passing through the glass and around which the glass is melted, and an incandescent conductor placed in the electric circuit."

3. Patent No. 230,255, dated July 20th, 1880, is for

"The method of forming electric lamps, consisting in separately forming the inclosing globe and the supporting bulb for the incandescent conductor, attaching the wires and incandescent conductor thereto, and then hermetically uniting the parts prior to the formation of the vacuum."

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4. Patent No. 251,540, dated December 27, 1881, is for

"An incandescing carbon conductor for electric lights, made from cane bamboo or similar fibre."

5. Patent No. 251,554, dated December 27, 1881, is for

"1. The combination with an incandescent electric lamp and its socket detachable from each other, and adapted to be used in a complete or round wire circuit, of controllable means for positively holding them in position together, and means for automatically completing the circuit connections between them through both limbs or members of the circuit upon placing them together in position.

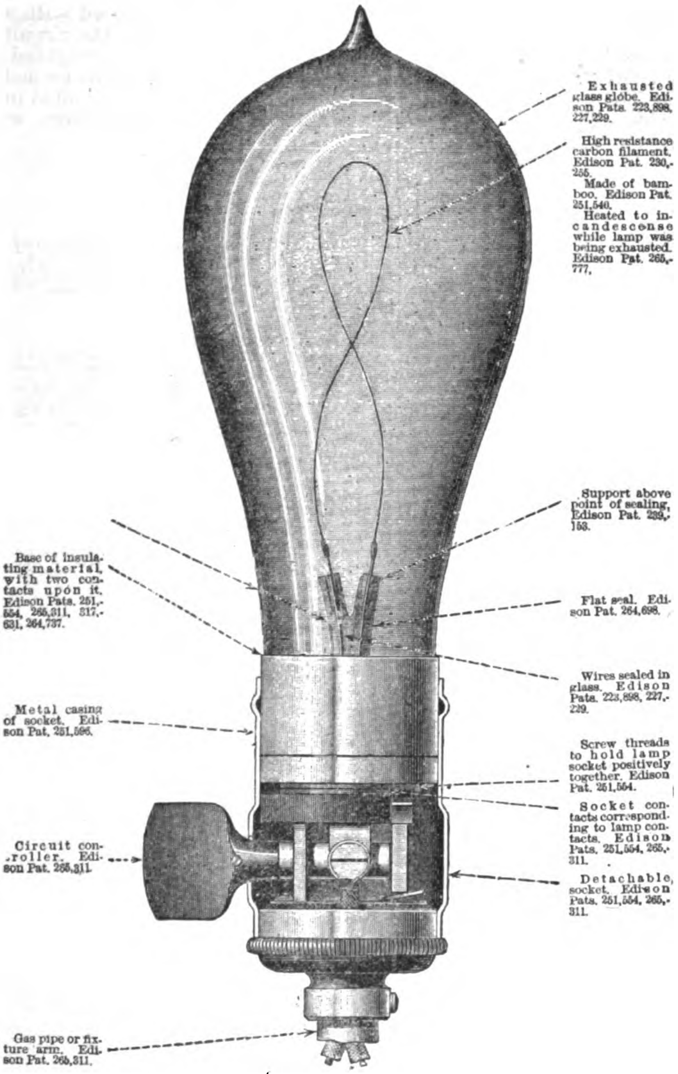
"2. An incandescent electric lamp having contact-plates or rings upon its neck or base arranged one above the other on the base of the lamp forming the terminals of both limbs or members of a complete or round wire circuit.

"3. The combination with a separate removable incandescent electric lamp and its socket of means for holding them positively in position relatively to each other."

6. Patent No. 264,698, dated September 19, 1882, is for

"1. In an incandescent electric lamp the central tube of support formed with a solid, flat portion at its upper extremity, through which the leading-in conductors pass and in which they are sealed.

"2. The method of sealing the leading-in conductors into the central tubular carbon support of an incandescing electric lamp, consisting in squeezing the open upper end of the tube upon such conductors and at the same time closing air tight such end of the tube."



Consolidated Co. (Sawyer-Man) Infringements of the Edison Patents.

7. Patent No. 264,737, dated September 19, 1882, is for

"1. An incandescing electric lamp having an irregularly shaped neck in combination with a collar attached to said neck, and metallic terminals secured to said collar and connected with the leading-in wires of the lamp."

8. Patent No. 265,311, dated October 3, 1882, is for

"1. A separate electric lamp, consisting essentially of an enclosing globe made entirely of glass, and incandescing material secured therein, conductors leading thereto and sealed in the glass where they pass therethrough, and a base of insulating material in which the neck of the globe is secured, said base being provided with metallic contact-plates to which the conductors leading into the globes are secured at their outer ends.

"2. A socket for an electric lamp adapted to be placed upon a gas pipe or other suitable support, and provided with contact-plates forming the terminals of an electric circuit.

"3. The combination with a bracket or chandelier arm, or other gas or hollow pipe, containing the wires of an electric circuit, of a socket or holder for an electric lamp adapted to be secured therein, and to receive and support the lamp, and provided with contact-plates forming the terminal of the wires of the electric circuit.

"4. A socket for an electric lamp adapted to be placed upon a gas pipe or other suitable support, and provided with contact-plates forming the terminals of an electric circuit, and also provided with a circuit controller inserted in one branch of the circuit for controlling the circuit."

9. Patent No. 265,777, dated October 20, 1882, is for

"The method of treating the carbon filament of an incandescing electric lamp, consisting in raising such carbon filament to incandescence during the latter part of the process of exhausting the lamp globe, whereby the air and gas are driven from the carbon filament and the flexibility of the filament is increased."

10. Patent No. 266,447, dated October 24, 1882, is for

"The method of manufacturing incandescent electric lamps, consisting in forming the inclosing globe or bulb directly from molten or pot glass, forming separately the supporting tube or neck for the incandescent conductor, sealing therein the leading-in wires, attaching the carbon thereto and then hermetically uniting the parts by welding together prior to the exhaustion of the lamp."

11. Patent No. 317,631, dated May 12. 1885, is for

"In an incandescing electric lamp, the combination with the glass inclosing globe and the neck thereof, of contact-plates joined together and held upon the neck of the lamp by plastic material."

12. Patent No. 251,596, dated December 27th, 1881, is for

"In a socket for electric lamps, the combination, with interior insulating portions provided with circuit connections, of exterior metal portions, forming a covering therefor."

The following named patents are some of those owned by the Edison Electric Light Co., the devices covered by which are not used by that company but are employed in lamps made by other electric lamp manufacturers:

1. Patent No. 239,153, dated March 22, 1881, is for

"The combination with the glass inclosing globe and incandescing conductor of an electric lamp, of a support hermetically sealed to the globe and supporting the carbons at a distance above the point of sealing."

2. Patent No. 307,029, dated October 21, 1884, is for

"The process of forming flexible incandescing filaments for electric lamps, consisting in first forming a straight filament of carbonizable substance, then carbonizing the same and finally bending the flexible filament thus formed into the desired shape."

In addition to the patents above enumerated, which relates only to the lamp itself, the Edison company is the owner of other patents covering other details of lamp construction, and of various devices, such as dynamo-electric machines, meters, motors, regulators, etc., which are or may be required to form a complete and perfect system of electric lighting or distribution.

The following is a complete list of the Edison company's patents:

No.	Date.	Title of Patent.
181,618	August 29, 1876.	Electric Lighting.
214,636	April 22, 1879.	Improvement in Electric Lights.
214,637	" 22, "	" " Thermal Regulators.
218,166	August 5, "	" " Magneto-Electric Machines.
218,167	" 5, "	" " Apparatus for Electric Lights.
218,866	" 26, "	" " Electric Lighting Apparatus.
219,393	Sept. 9, "	" " Dynamo-Electric Machines.
219,628	" 16, "	" " Electric Lights.
222,881	Dec. 23, "	" " Magneto-Electric Machines.
223,112	" 30, "	Method for Measuring Electricity.
223,898	Jan. 27, 1880	Electric Lamp.
224,329	Feb. 10, "	Electric Lighting Apparatus.
227,226	May 4, "	Safety-Conductor for Electric Lights.
227,227	" 4, "	Electric Light.
227,228	" 4, "	" "
227,229	" 4, "	" "
228,617	June 8, "	Brake for Electro-Magnetic Motors.
230,255	July 20, "	Method of Manufacturing Electric Lamps.
237,732	Feb. 15, 1881	Electric Light.
238,868	March 15, "	Manufacture of Carbons, Incandescent Lamps.
239,147	" 22, "	System of Electric Lighting.
239,148	" 22, "	Treating Carbons for Electric Lamps.
239,149	" 22, "	Incandescing Electric Lamp.
239,150	" 22, "	Electric Lamp.
239,151	" 22, "	Method of forming Enlarged Ends on Carbon Filaments
239,152	" 22, "	System of Electric Lighting.
239,153	" 22, "	Electric Lamp.
239,372	" 29, "	Testing Electric Light Carbons.
239,373	" 29, "	Electric Lamp.
239,374	" 29, "	Regulating the Generation of Electric Currents.
239,745	April 5, "	Electric Lamp.
240,678	" 26, "	Webermeter.
242,896	June 14, "	Incandescent Electric Lamp.
242,897	" 14, "	" " "
242,898	" 14, "	Magneto or Dynamo-Electric Machine.
242,899	" 14, "	Electric Lighting.
242,900	" 14, "	Manufacturing Carbons for Electric Lamps.
242,901	" 14, "	Electric Meter.
248,416	Oct. 18, "	Manufacture of Carbons for Electric Lamps.
248,417	" 18, "	Manufacturing " " " "
248,418	" 18, "	Electric Lamp.
248,419	" 18, "	Electric Lamp.
248,420	" 18, "	Fixture and Attachment for Electric Lamp.
248,421	" 18, "	Current Regulator for Dynamo-Electric Machines.
248,422	" 18, "	System of Electric Lighting.
248,423	" 18, "	Carbonizer.
248,424	" 18, "	Fitting and Fixture for Electric Lamps.
248,425	" 18, "	Apparatus for Producing High Vacuums.
248,426	" 18, "	Apparatus for Treating Carbons.
248,427	" 18, "	" " " "
248,428	" 18, "	Manufacture of Incandescent Electric Lamps.
248,429	" 18, "	Electric Motor.
248,430	" 18, "	Electro-Magnetic Brake.
248,433	" 18, "	Vacuum Apparatus.
248,434	" 18, "	Governor for Electric Engines.
248,435	" 18, "	Utilizing Electricity as a Motive Power.
248,436	" 18, "	Depositing Cell for Plating the Connections of Elec- tric Lamps.

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No.	Date.	Title of Patent.
248,437	Oct. 18, 1881	Apparatus for Treating Carbons.
248,565	" 18, "	Meter.
251,536	Dec. 27, "	Vacuum Pump.
251,537	" 27, "	Dynamo-Electric Machine.
251,538	" 27, "	Electric Light.
251,539	" 27, "	Electric Lamp.
251,540	" 27, "	Carbon for Electric Lamps.
251,541	" 27, "	Electro-Magnetic Motor.
251,542	" 27, "	System of Electric Lighting.
251,543	" 27, "	Electric Lamp.
251,544	" 27, "	Manufacture of Electric Lamps.
251,545	" 27, "	Electric Meter.
251,546	" 27, "	Electric Lamps.
251,547	" 27, "	Electric Governor.
251,548	" 27, "	Incandescent Electric Lamp.
251,549	" 27, "	Electric Lamp and the Manufacture thereof.
251,550	" 27, "	Magneto or Dynamo-Electric Machine.
251,551	" 27, "	System of Electric Lighting.
251,552	" 27, "	Underground Conductor.
251,553	" 27, "	Electric Chandelier.
251,554	" 27, "	Electric Lamp and Socket.
251,555	" 27, "	Regulator for Dynamo-Electric Machine.
251,556	" 27, "	" " " "
251,557	" 27, "	Webermeter.
251,558	" 27, "	"
251,559	" 27, "	Electrical Drop-Light.
251,596	" 27, "	Socket for Electric Lamps.
257,276	May 2, 1882	Switch for Electric Light Circuits.
257,277	" 2, "	Socket for Electric Lamps.
260,562	July 24, "	Switch and Indicator for Electric Lamps.
12,631	" 27, "	Design for an Incandescent Electric Lamp.
263,133	August 22, "	Dynamo or Magneto-Electric Machine.
263,134	" 22, "	Regulator for Dynamo or Magneto-Electric Machines.
263,135	" 22, "	Electric Lamp.
263,136	" 22, "	Regulator for Dynamo or Magneto-Electric Machines.
263,137	" 22, "	Electric Chandelier.
263,138	" 22, "	Electric Arc Light.
263,139	" 22, "	Manufacture of Carbons for Electric Lamps.
263,140	" 22, "	Dynamo-Electric Machine.
263,141	" 22, "	Straightening Carbons of Electric Incandescent Lamps.
263,142	" 22, "	Electrical Distribution System.
263,143	" 22, "	Magneto or Dynamo-Electric Machine.
263,144	" 22, "	Mold for Carbonizing Incandescents.
263,145	" 22, "	Making Incandescents.
263,146	" 22, "	Dynamo or Magneto-Electric Machines.
263,147	" 22, "	Vacuum Apparatus.
263,148	" 22, "	Dynamo or Magneto-Electric Machine.
263,149	" 22, "	Commutator for Dynamo or Magneto-Electric Machines.
263,150	" 22, "	Magneto or Dynamo-Electric Machine.
263,878	Sept. 5, "	Electric Lamps.
264,298	" 12, "	Coupling Device for Electrical Conductors.
264,299	" 12, "	Connection for Electric Circuits.
264,642	" 19, "	Electric Distribution and Translation System.
264,643	" 19, "	Magneto-Electric Machine.
264,645	" 19, "	System of Conductors for the Distribution of Electricity.
264,646	" 19, "	Dynamo or Magneto-Electric Machine.
264,647	" 19, "	" " " "
264,648	" 19, "	" " " "
264,649	" 19, "	" " " "
264,650	" 19, "	Manufacture of Incandescing Electric Lamps.
264,651	" 19, "	Incandescent Electric Lamp.
264,652	" 19, "	" " "
264,653	" 19, "	" " "
264,654	" 19, "	" " "
264,655	" 19, "	" " "
264,656	" 19, "	" " "
264,657	" 19, "	" " "
264,658	" 19, "	Regulator for Dynamo-Electric Machines.
264,659	" 19, "	" " " "
264,660	" 19, "	" " " "
264,661	" 19, "	" " " "
264,662	" 19, "	" " " "
264,663	" 19, "	" " " "
264,664	" 19, "	" " " "
264,665	" 19, "	" " " "
264,666	" 19, "	" " " "
264,667	" 19, "	" " " "
264,668	" 19, "	" " " "
264,669	" 19, "	" " " "
264,670	" 19, "	" " " "
264,671	" 19, "	" " " "
264,672	" 19, "	" " " "
264,673	" 19, "	" " " "
264,698	" 19, "	Electric Lamp.
264,737	" 19, "	Incandescing Electric Lamp.
265,311	Oct. 3, "	Electric Lamps and Holders for same.
265,774	" 10, "	Maintaining Temperature in Werbermeters.
265,775	" 10, "	Electric Arc Light.
265,776	" 10, "	Electric Lighting System.
265,777	" 10, "	Treating Carbons for Electric Lamps.
265,779	" 10, "	Regulator for Dynamo-Electric Machines.
265,780	" 10, "	" " " "
265,781	" 10, "	" " " "
265,782	" 10, "	" " " "
265,783	" 10, "	" " " "
265,784	" 10, "	" " " "
265,785	" 10, "	Dynamo-Electric Machine.
265,786	" 10, "	Apparatus for the Electrical Transmission of Power.
265,858	" 10, "	Regulator for Dynamo-Electric Machines.
265,859	" 10, "	" " " "
266,447	" 24, "	Electric Incandescent Lamps.
266,588	" 24, "	Vacuum Apparatus.
266,793	" 31, "	Electrical Distribution Systems.
266,808	" 31, "	Safety-Catch.
268,205	Nov. 28, "	Dynamo or Magneto-Electric Machines.
268,206	" 28, "	Incandescing Electric Lamps.
271,613	Feb. 6, 1883.	Manufacture of Incandescing Electric Lamps.
271,614	" 6, "	Shafting.
271,615	" 6, "	Governors for Dynamo-Electric Machines.
271,616	" 6, "	Regulators for Dynamo-Electric Machines.
271,628	Feb. 6, 1883	Secondary Batteries.
271,654	" 6, "	Regulators for Dynamo-Electric Machines.
273,485	March 6, "	Incandescing Electric Lamps.
273,486	" 6, "	" " "
273,487	" 6, "	Regulators for Dynamo-Electric Machines.
273,488	" 6, "	" " " "
273,491	" 6, "	Regulators for Driving Engines of Electrical Generators.
273,492	" 6, "	Secondary Batteries.
273,493	" 6, "	Valve Gear for Electrical Generator Engines.
273,828	" 13, "	System of Underground Conductors for Electrical Distribution.
274,290	" 20, "	Systems of Electrical Distribution.
274,291	" 20, "	Molds for Carbonizing.
274,292	" 20, "	Secondary Batteries.
274,293	" 20, "	Electric Lamps.
274,294	" 20, "	Incandescing Electric Lamps.
274,295	" 20, "	" " "
274,296	" 20, "	The Manufacture of Incandescents.
275,612	April 10, "	Manufacture of Incandescing Electric Lamps.
275,613	" 10, "	Incandescing Electric Lamps.
275,749	" 10, "	Connection for Electric Light Fixtures.
276,232	" 24, "	Means for Operating and Regulating Electrical Generators.
276,233	" 24, "	Electrical Generators and Motors.
13,940	May 29, "	Design for Incandescing Electric Lamps.
278,413	" 29, "	Regulator for Dynamo-Electric Machine.
278,414	" 29, "	" " " "
278,415	" 29, "	Manufacturing of Incandescing Electric Lamps.
278,416	" 29, "	" " " " "
278,417	" 29, "	" " " " "
278,418	" 29, "	Apparatus for Translating Electric Currents from High to Low Tension.
278,419	" 29, "	Dynamo-Electric Machine.
278,535	" 29, "	System of Electrical Distribution.
280,563	July 3, "	Electrical Measuring Apparatus.
280,727	" 3, "	System of Electrical Distribution.
281,349	" 17, "	Regulator for Dynamo-Electric Machines.
281,350	" 17, "	" " " "
281,351	" 17, "	Electrical Generator.
281,352	" 17, "	Webermeter.
281,353	" 17, "	Dynamo-Electric Machine.
281,576	" 17, "	Safety-Catch for Electric Light Circuits.
283,270	August 14, "	Incandescing Electric Lamp.
283,983	" 28, "	System of Electrical Distribution.
283,984	" 28, "	" " "
283,985	" 28, "	" " "
283,986	" 28, "	" " "
287,501	Oct. 30, "	Electrical Testing.
287,511	" 30, "	Electric Regulator.
287,512	" 30, "	Dynamo-Electric Machine.
287,513	" 30, "	" " "
287,514	" 30, "	" " "
287,515	" 30, "	System of Electrical Distribution.
287,516	" 30, "	" " "
287,517	" 30, "	" " "
287,518	" 30, "	Manufacturing Incandescing Electric Lamps.
287,519	" 30, "	Incandescing Electric Lamp.
287,520	" 30, "	Incandescing Conductor for Electric Lamps.
287,521	" 30, "	Dynamo-Electric Machine.
287,522	" 30, "	Mold for Carbonizing.
287,523	" 30, "	Dynamo-Electric Machine.
287,524	" 30, "	Regulator for Dynamo-Electric Machine.
287,525	" 30, "	Regulator for Systems of Electric Distribution.
287,532	" 30, "	Junction for Electrical Conductors.
287,533	" 30, "	Safety-Catch for Electric Circuits.
288,318	Nov. 13, "	Regulator for Dynamo-Electric Machine.
293,432	Feb. 12, 1884.	Electrical Generator or Motor.
293,434	" 12, "	Incandescent Electric Lamp.
293,435	" 12, "	Electrical Meter.
297,580	April 29, "	Electric Arc Lights.
297,581	" 29, "	Incandescent Electric Lamp.
297,582	" 29, "	Dynamo-Electric Machine.
297,583	" 29, "	" " "
297,584	" 29, "	" " "
297,585	" 29, "	Incandescing Conductor for Electric Lamps.
297,586	" 29, "	Electrical Conductor.
297,587	" 29, "	Dynamo-Electric Machine.
298,658	May 13, "	Socket for Incandescent Electric Lamps.
298,679	" 13, "	Treating Carbons for Electric Lights.
298,954	" 20, "	Dynamo-Electric Machine.
298,955	" 20, "	" " "
298,956	" 20, "	Operating Dynamo-Electric Machines.
304,082	August 26, "	Electrical Meter.
304,083	" 26, "	Dynamo-Electric Machine.
304,084	" 26, "	Device for Protecting Electric Light Systems from Lightning.
304,085	" 26, "	System of Electrical Distribution.
304,086	" 26, "	Incandescent Electric Lamp.
304,087	" 26, "	Electrical Conductor.
307,029	Oct. 21, "	Filament for Incandescent Lamps.
307,030	" 21, "	Electrical Meter.
307,031	" 21, "	Electrical Indicator.
314,582	March 21, 1885.	Safety-Catch for Electric Circuits.
317,632	May 12, "	Incandescent Electric Lamp.
317,633	" 12, "	" " "
328,572	Oct. 20, "	Commutator for Dynamo-Electric Machine.
328,573	" 20, "	System of Electric Lighting.
328,574	" 20, "	" " "
328,575	" 20, "	" " "
334,853	Jan. 26, 1886.	Mold for Carbonizing.
339,279	April 6, "	System of Electric Distribution.
341,644	May 11, "	Incandescent Electric Lamp.
341,839	" 11, "	" " "

The foregoing cuts are designed to illustrate the infringement of the Edison patents by the lamps of other makers. They are taken directly from the lamps and sockets themselves.

It will be apparent that in each of the infringing lamps, where it is attempted to avoid any one of the Edison patents, this is

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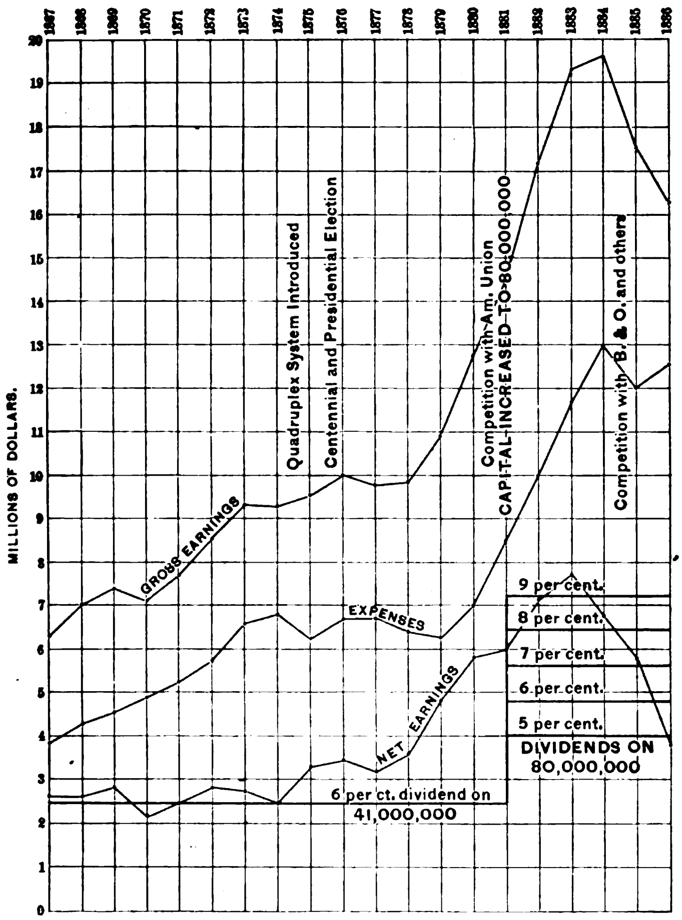
done by the omission of some useful part or device, or by the substitution of inferior ones to those employed by the Edison company.

All lamps now on the market, it will be seen, infringe a greater or less number of the Edison patents, and it is impossible to construct a commercially practical incandescent electric lamp without using many of the devices covered by the patents owned by the Edison Electric Light Company.

CHART SHOWING GROSS EARNINGS, EXPENSES AND NET EARNINGS OF THE WESTERN UNION TELEGRAPH COMPANY FOR TWENTY YEARS.



SYSTEM OF ELECTRIC DISTRIBUTION.

Specification forming part of Letters Patent, No. 351,589, dated October 26, 1886, to LUCIEN GAULARD AND JOHN D. GIBBS, OF THE COUNTY OF MIDDLESEX, ENGLAND, ASSIGNORS TO GEORGE WESTINGHOUSE, JR., OF PITTSBURGH, PENN.

Application filed March 6, 1886. Serial No. 194,229. (No model.)

To all whom it may concern:

BE IT KNOWN, That we, Lucien Gaulard, a citizen of the republic of France, and John Dixon Gibbs, a subject of the Queen of Great Britain, both of the county of Middlesex, England, have jointly invented certain new and useful Improvements in Methods and Apparatus for the Distribution and Conversion of Electric Energy, of which the following is a specification:—

Our invention relates to the distribution of electrical energy for industrial purposes, and it consists in an improved art or method, and an organization of apparatus whereby the same is carried into effect, by means of which we are enabled to transmit from a central or supply station through a main conductor a primary electric current of comparatively small quantity but of high potential, and at a point or points more or less distant where the said electric energy is to be utilized, to transfer the energy residing in such primary current of high potential, into one or more secondary currents of lower potential but of greater quantity. To this end, the invention comprises certain combinations of apparatus having an organization and mode of operation particularly adapted to effect such transference of electric energy.

By means of our improved method and apparatus we are enabled to convey a useful quantity of electric energy to a much greater distance than has heretofore been practicable, while the cost of the necessary plant for electric lighting and other analogous purposes, especially that of the main electrical conductors, is very materially diminished.

The accompanying drawings represent an organization of apparatus which we have found to be well adapted for carrying out our invention.

Figure 1 is a theoretical plan showing the general principle of the apparatus, figure 2 is a transverse vertical section of one form of converter, and figure 3 is a diagram showing one plan of arranging the apparatus when the transference of energy is to be effected at more than one point.

In the drawing, D represents a dynamo-electric generator of suitable construction, organized for the production in the main line of alternating currents, that is to say, successive electric currents or pulsations alternately of positive and negative polarity and of equal potential and duration. We have found by experiment that the dynamo-electric machine of Alteneck, described in United States Letters Patent No. 234,353, of November 9th, 1880, is well adapted for our purpose; but we do not desire to confine ourselves to any particular construction of generators for setting up alternating currents in the line, as there are many forms of these known and used which will serve sufficiently well.

In order to operate a dynamo-electric machine for the production of alternate currents, it is necessary to provide some means for maintaining its magnetic field. This may be accomplished by a separate current derived from an independent dynamo machine, technically termed the "exciter." Such independent exciter is shown in the drawing at E. It may be an ordinary direct current dynamo machine, of any suitable construction. The current of the exciter E is conducted from its terminals p, p, by means of wires 1 and 2, to and through the field-magnet helices of the main dynamo or generator D.

In order to vary when required the electromotive force of the generator D, it is convenient to effect a corresponding variation in the strength of the current in the field produced by the exciter E. This may be done in the case of a shunt-wound exciter, by an adjustable resistance inserted in the field of the exciter. We have shown this plan in the drawings. R is a rheostat composed of a series of graduated resistance coils r, r^1, r^2, etc. A movable contact-arm or other equivalent devices is provided, by means of which the current for maintaining the field produced by the exciter E may conveniently be regulated. The same result may be reached in other well-known ways. The power for operating the main dynamo D, as well as the exciter E, is furnished by a suitable steam engine or other convenient motor M.

At a point where the electric current is to be utilized for any suitable purpose, as for instance, in one or more incandescent electric lamps, we place one or more secondary generators of converters, as shown at C in figure 1. The general principle of our secondary generator is analagous to that of the well-known inductorium or induction coil, with this exception, that while the induction coil has heretofore usually been employed to transfer electric energy from currents of low potential and great quantity into currents of high potential and small quantity, the function of the secondary generator or converter as applied in our invention is precisely the reverse of this, namely, to transfer electric energy from currents of high potential to currents of low potential and increased quantity. We have constructed converters for effecting this result in a variety of forms, all of which involve the same principle. In order that this principle may be better understood, we will describe the construction and mode of operation of a simple form of the converter which we have shown at C in figure 1. Two iron cores b, b^1, are preferably built up from a large number of small soft iron wires, insulated from each other and mechanically secured together in a solid bundle. It is usually preferable to unite the ends of the cores so that they will become magnetically continuous. In figure 3 for example, we have shown the cores in the form of a rectangle; but the core or cores may be straight cylinders, or closed figures of oval, annular, horseshoe or other shape, this being merely a matter of convenience in construction or economy in operation, but involving no change of principle. Around the cores b, b^1, the primary electric conductors 4 and 5 are disposed helically in the manner shown in the drawing, which, however, is intended to represent the arrangement of these conductors in a symbolical or typical manner only, the actual construction being preferably similar to that shown in figure 2, hereinafter to be described. By inspection of the drawing it will be seen that one conductor, 4, is coiled upon the left-hand portion of the core, and the other similar conductor, 5, upon the right hand portion, and the two conductors 4 and 5 are then connected at their adjacent ends, that a current may traverse them in series and thus develop magnetism in the iron cores b, b^1, so as to establish a magnetic field surrounding or enveloping said cores and adjacent thereto. The secondary conductors I. and II. are disposed in precisely the same manner around the cores b and b^1, and within the same magnetic field. In the particular arrangement shown in figures 1 and 3 of the drawing, each convolution of the secondary conductor is interposed between two adjacent convolutions of the primary conductor, so that the number of convolutions as well as their mean distance from the axis

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of the core is the same. Experience indicates that the more nearly the last mentioned relation is preserved, the higher will be the efficiency of the apparatus. The relative disposition of the primary and secondary helices may otherwise be greatly varied without material change in the result; for example, one may be superposed upon the other as in figure 2, or the two may be placed upon different parts of the same core or cores, according to circumstances. It is to be observed that the secondary conductors shown in figure 1 of the drawings are not united in ser.es like the primary conductors, but their ends are joined together as shown at III. and IV., in parallel or multiple arc, and from the last named junction points of the secondary, the conductors V. and VI. are led to an electric lamp or other translating device L by which the circuit is completed.

We will now describe the mode of operation of the apparatus. When the dynamo-electric generator D is set in operation, a rapid succession of alternating positive and negative currents or pulsations of equal potential and duration, technically termed an alternating current, is set up in the main or primary conductor, the path of which may be traced in figure 1 as follows:—From one terminal of the generator D by the line conductor 3 to the primary conductor 4, 5 of the secondary generator C, thence returning by the line conductor 6 to the opposite terminal of the generator. The alternate current proceeding from the primary generator D, by its inductive action in the secondary generator C, creates a magnetic field of alternate polarity, and this alternation of quantity and reduction of potential in the secondary circuit is effected. Let it be assumed that we have an electric lamp, as L in figure 1, so constructed as to work at maximum efficiency when rendered luminous by an electric current of 1 ampere. Let it also be assumed that, for economical or other reasons, it is desired to employ an alternate current of 0.5 ampere only in the primary circuit. The necessary increase in the quantity of the secondary current will, in such case, be effected by the apparatus when arranged precisely as shown in the figure, for as the primary conductor of the converter C is connected in series, while the secondary conductor (with an equal number of convolutions situated in the same magnetic field) is arranged with one-half its convolutions in multiple arc with the other half, the result will be precisely the same as if the actual number of convolutions of the secondary conductor were only half as many as those of the primary. The total resistance of the secondary conductor when thus connected, is obviously only one-fourth as great as that of the primary, the secondary being double the cross-section, and virtually only one half the length of the primary.

When an electric current of alternating polarity is caused to pass through the primary conductor of the converter C—figure 1—it creates by electro-magnetic induction a magnetic field, the intensity of which, within the ordinary limits of working, is proportional to the current (expressed in amperes) passing through the conductor. Each alternation so produced in the magnetism of the field tends to set up a definite electromotive force in each separate convolution

Fig. 1.

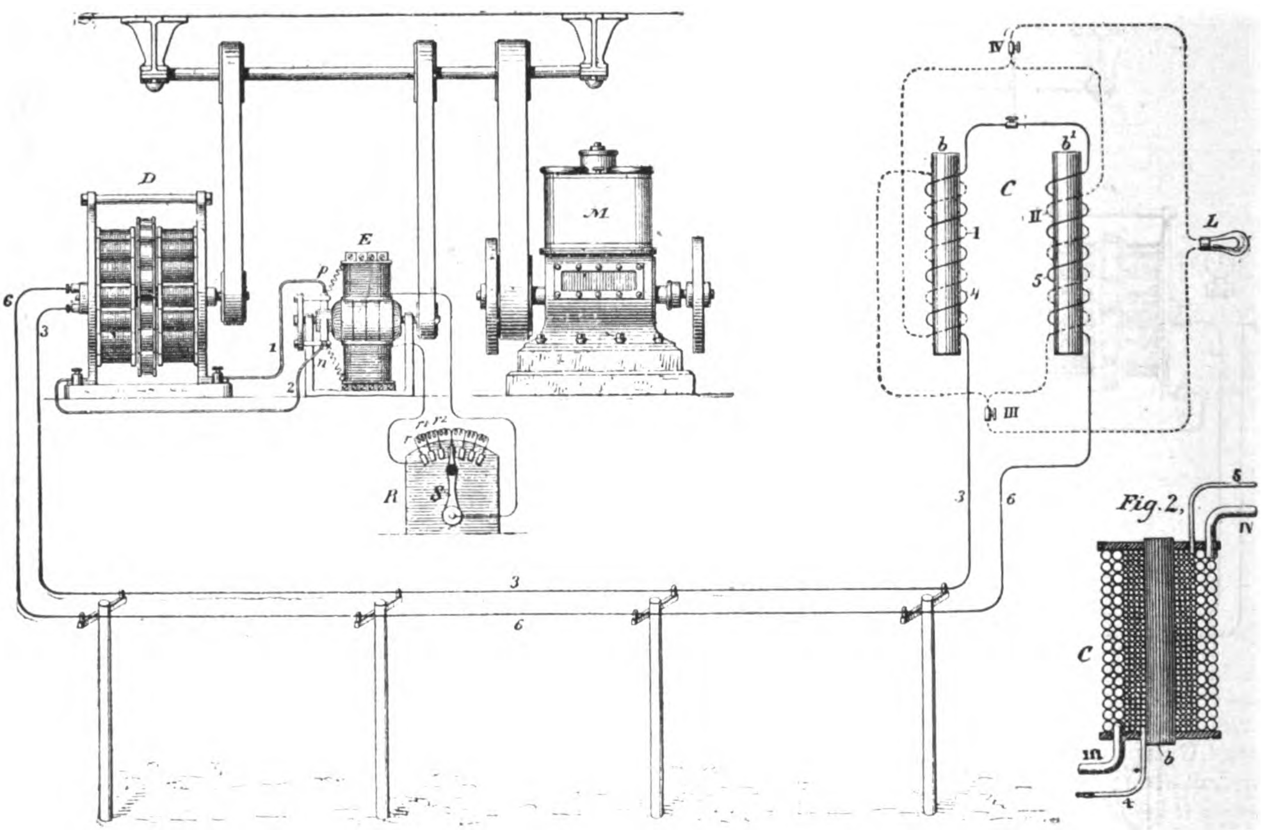

Fig. 2.

the magnetism of the field, in accordance with a well-known law, generates by inductive reaction an alternate current in the closed circuit of a secondary conductor situated within it. This secondary current may be utilized for electric lighting or other purposes in the same manner that primary currents ordinarily are, by including proper translating devices in said secondary circuit.

The most important and characteristic feature of our invention is that which renders it possible to make use of alternating and equal positive and negative currents of moderate quantity but of very high potential, in the primary or main line circuit, and to convert these into secondary or induced currents of much greater quantity but of corresponding lower potential at the place of consumption, which secondary currents are employed to do the required work. This is a result, the attainment of which is of the utmost importance in the art of electrical distribution, as it renders practicable the employment of insulated main conductors, of comparatively small size and moderate cost, for the transmission of large amounts of energy to great distances.

We will now explain the means by which this increase of of any conductor traversing the field. In the primary conductor this electromotive force opposes itself temporarily to the primary or magnetizing current, but as it is of inferior and rapidly decreasing potential, it acts merely to delay, and not to prevent, the magnetization of the field. An approximately equal electromotive force is at the same time set up in each convolution of the secondary conductor, but, as the latter (in the present example) makes only half the number of convolutions within the field, the total electromotive force of the secondary current will be only one-half that of the primary current. Inasmuch, however, as the value of any current is expressed by the quotient of the electromotive force divided by the resistance, and as the resistance of the secondary coil is only one-fourth that of the primary, the actual number of amperes in the secondary current will be approximately twice as many as in the primary current. Strictly speaking, however, the inductive action may be said to be determined, not by the number of convolutions but by the extent of conductor, measured in linear units, which is in inductive relation to the magnetic field, assuming the lines of force in such field to be uniformly distributed. In order to produce a proper result, it is preferable that the resistance offered by that portion of the linear

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conductor in the magnetic field which is traversed by the primary current, shall exceed the resistance of the conductor in the same field traversed by the secondary current, in an inverse ratio to the increase in current strength or reduction of potential which it is desired to effect.

Any required number of converters, of the general construction described, may have their primary circuits united with, or included in, the conductors leading from the primary generator. The manner of connecting such converters, whether in series, multiple arc, multiple series, or otherwise, will be understood by those skilled in the art to which our invention relates, without the necessity of further explanation. One arrangement, however, is indicated in figure 3, in which a second converter, C′, is placed in circuit, provided with a secondary conductor and an independent group of lamps. The primary current traverses the circuit 3, 4, 5, 6, 7, 8, 9, passing through the primary wires of both converters, and the separate groups of lamps are shown at L and L′. We do not herein claim the connection of the converters in the line, in any other arrangement than we have illustrated in the drawings.

It must not be forgotten, however, that the consumption of energy in the main or primary circuit will, in all cases, bear a certain definite ratio to the work which is being done, or at least to the resistance which is offered at any given time in the secondary circuits of the converters, whether one or many. The attendant at the generator, by means of an electro-dynamometer or other suitable current indicator, G—figure 3—can readily detect any change in the strength of the current due to variations in the consumption, and, by moving the arm S, can correspondingly raise or lower the electromotive force of the generator D, so as to bring the current back to its normal strength.

The converter C may be constructed in various ways. We have attained excellent results by constructing it in the manner more particularly shown and described in prior United States patents, Nos. 297,924 of April 29th, 1884, and 316,354 of April 21st, 1885. Another form, which gives excellent results in practice, is shown in figure 2, in which *b* is a core formed of a bundle of iron wires, around which the primary wire 4 is coiled in a helix of the ordinary form. The helix of the secondary wire III, IV., is superposed upon that of the primary, in the manner shown. The sectional area of the secondary wire is here shown as four times that of the primary, while the number of convolutions is only one-fourth as great. We nevertheless do not desire to confine ourselves to any particular construction of the converter, as this is quite immaterial so long as the essential principles which we have hereinbefore set forth are not departed from.

We claim as our invention:—

1. The hereinbefore-described art or method of electrical distribution and conversion, which consists in establishing in a closed electric circuit, a current of alternate and equal positive and negative potential, producing by the influence of such current an inductive field of alternate polarity, and thereby inducing in translating devices situated in an independent closed circuit traversing such field, a similar alternating secondary current of greater quantity and less potential than the originating or producing current.

2. In a system of electrical distribution, an inductorium or converter, in which the length of that portion of the conductor traversed by the primary current within the magnetic field created by itself, exceeds the length within the same field of the conductor traversed by the secondary current, in combination with a dynamo-electric generator producing alternating electric currents or pulsations of equal potential and duration, and translating devices actuated by said secondary current.

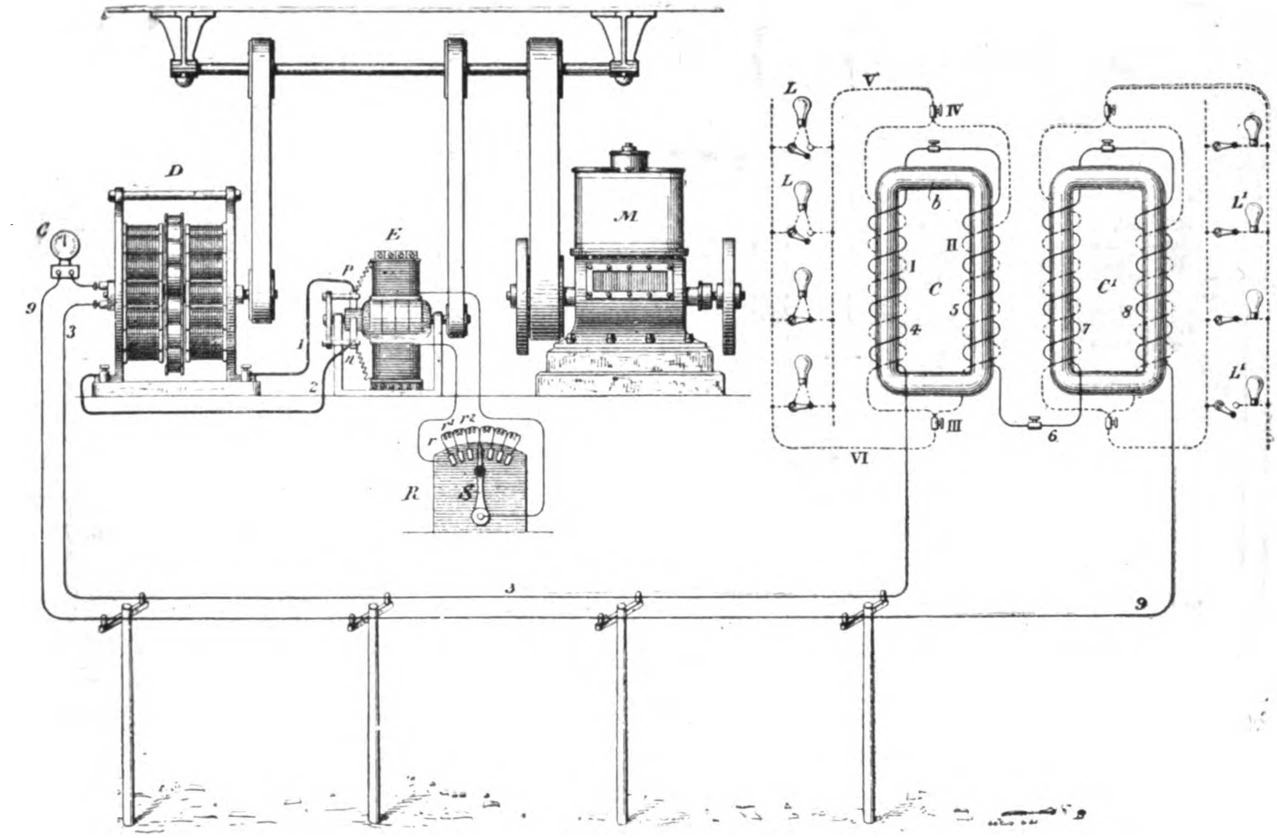
3. In a system of electrical distribution, an inductorium or converter, in which the resistance of that portion of the conductor traversed by the primary current within the magnetic field created by itself, exceeds the resistance of that portion of the conductor traversed by the secondary current which lies within said field, in combination with a dynamo-electric generator producing alternating currents or pulsations of equal potential and duration, and translating devices actuated by said secondary current.

4. In a system of electrical distribution, a dynamo-electric machine, organized for the production of alternate positive and negative currents, equal to each other in potential and duration, in combination with the primary circuit of an inductorium or converter organized to induce in its secondary circuit alternating currents of lower potential and greater quantity than those of the primary circuit, and one or more translating devices actuated by said secondary currents.

5. In a system of electrical distribution, the combination of an inductorium or converter, having its primary and secondary circuits constantly closed, a dynamo-electric generator for producing alternating currents of equal potential and duration included in said closed primary circuit, and one or more translating devices included in said closed secondary circuit, substantially as set forth

[NOTE.—The claims of this patent were refused by the Primary Examiner on the ground of lack of patentable novelty, but were allowed on appeal to the Board of Examiners in Chief.]

Fig. 3.



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THE WIRE GAUGE QUESTION.

The Electrical World of Oct. 2d, prints the following interesting correspondence :

To the Editor of The Electrical World:

SIR : At the risk of overburdening your pages with correspondence on the wire gauge question, I send you a letter from Messrs. Felten & Guilleaume, of Mülheim, near Cologne, the largest makers in the world of iron and steel telegraph wire.

It is only necessary to observe that the statements made as to usage in different countries refer to line wire, and not to sheet metal, fine copper wires, etc. The gauges mentioned as in use on the continent are all based on the millimetre system.

I only wish that their impression as to the tendency in America toward the adoption of the metric system were correct, but I fear there is little use hoping for so desirable a change.

ANTWERP, Belgium. F. R. WELLES,

Messrs. Felten & Guilleaume say in their letter to Mr. Welles, giving him the information for which he asked :

"There is no doubt but that English wire gauges have been largely used on the continent of Europe in former times, and especially the so-called Birmingham wire-gauge. At present this wire gauge is still used in Belgium, Russia, Sweden, Norway, and Denmark. The new standard gauge is only being introduced by degrees. In Germany, the Birmingham wire gauge was used up to the year 1873, although the ancient Westphalian wire gauge and also the French gauge (or jauge de Paris) were used besides, to a small extent. In 1872, the German wire drawers adopted the so-called millimetre wire gauge, which is at present used throughout Germany and Austria, other wire gauges only being used occasionally. The millimetre gauge indicates the size of wire by tenths of a millimetre, so that for instance the No. 42 wire would be 4.2 mm. thick, and No. 4 wire would be 0.4 mm. thick. Certain standard sizes are, however, adopted by preference, coming up very nearly to the old Birmingham wire gauge, say :

No. of millim. gauge:									100	94	88	82	76
Thickness in millim.:									10.0	9.4	8.8	8.2	7.6
70	65	60	55	50	46	42	38	34	31	28	25	22	20
7.0	6.5	6.0	5.5	5.0	4.6	4.2	3.8	3.4	3.1	2.8	2.5	2.2	2.0
18	16	14	13	12	11	10	9	8	7	6	5½	5	4½
1.8	1.6	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.6	0.55	0.5	0.45
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2					
0.4	0.37	0.34	0.31	0.28	0.26	0.24	0.22	0.2					

"As regards the system of measurement employed in Germany, wire gauges, *i. e.*, plates of steel with notches representing the various sizes of wire, are still much used in the works, but in addition the micrometer or screw gauge is much employed, allowing the measurement of the size of wire to the smallest fraction of a millimetre.

"In France, Spain, Italy, Switzerland, Greece, and Asia Minor, the French gauge, and principally the so-called jauge de Paris of 1857, is used. This gauge indicates the size of wire by numbers having certain equivalents in millimetres; and, contrary to the Birmingham wire gauge, where the smallest number indicates the largest size, in the French gauge the smallest number indicates the smallest size.

"The jauge 'japy,' similar to the jauge de Paris, but with slightly smaller sizes for the different numbers, is also used to some extent in France and Switzerland ; for the finer wires, card wire, copper wire, etc., the so-called jauge 'carcasse' is in use.

"With regard to Great Britain and the British colonies, they all now use the new standard wire gauge. In the United States of America, hitherto the Stubbs' Birmingham wire gauge has, we believe, been mostly used, besides Washburn & Moen's, and Brown and Sharpe's wire gauges.

"If we are not mistaken there is a tendency in the United States to the adoption of the millimetre gauge. If this gauge should really be adopted in the states, the Americans will show that they are readier to take up an improvement than their English cousins, the millimetre gauge having been frequently proposed in England, but always declined on account of the conservative opposition it encountered. In South America both the Birmingham wire gauge or the new standard gauge and the jauge de Paris are used according to whether buyers have been accustomed to purchase in England or in France, the French imports of wire having of late been replaced by imports from Germany.

"We are used to sell in the export market to whatever gauge may be desired.

"In concluding, we beg to give you our opinion that the best system of measuring is the millimetre gauge, and that this gauge will be used to greater extent in the future ; this will, however, greatly depend upon whether England will do away with her ancient system of measures, weights and money, and replace it by the far simpler metric system. This, we believe, is only a question of time."

ANNUAL MEETING OF THE TELEGRAPHERS' MUTUAL BENEFIT ASSOCIATION.

The 20th annual meeting of the Telegraphers' Mutual Benefit Association was held in room 30 of the Western Union Building, on Wednesday afternoon, November 17. The meeting was called to order at four o'clock by the president, Mr. A. R. Brewer. The attendance was larger than usual, and included, probably for the first time, two of the lady members. Much interest was shown by the delegates and members present in the business and welfare of the association.

Among the New York members present were Messrs. Merrihew, Cockey, Dealy, O'Leary, Redding, Baker and Edwards, in addition to secretary Bruch and treasurer Mackay. Baltimore was represented by R. J. Bloxham ; Boston by G. L. Lang ; Chicago by Messrs. Jos. Uhrig and W. J. Lloyd ; Columbus by Messrs. A. M. Paddock and H. E. Rawson ; Jersey City by I. A. Van Dusen ; Philadelphia by S. S. Garwood, I. D. Maize, J. Wintrop and R. C. Mecreedy ; and Pittsburg by S. A. Duncan and M. M. Prescott.

After the question of credentials had been attended to, president Brewer made a brief address, in which he said : "It is a pleasure to welcome so many members to the annual meeting, and to see the yearly recurring evidence of the interest of the members in the association. Again, as in last year's report, I have the pleasure of stating that the number of members of both divisions has increased from the preceding year, the reserve fund has increased, and the number of assessments has again been reduced. The secretary's report will show a gain of over eight per cent. in the membership of the first division and over 17 per cent. in that of the second division. The reserve fund is now within $9,000 of the limit fixed by the by-laws. If the death rate does not increase, it is hoped that the fund will soon reach the limit for the existing membership. The steady and healthful growth of the association during the past year will be shown in detail by the reports of the secretary and treasurer, which follow."

The annual reports of the secretary and treasurer were then read, as follows :

		1st div.		2d div.
Membership, as per last annual report		2,872		323
Members admitted during year		316		62
		3,188		385
Members lapsed	64		3	
Members died	22		3	
	—	86	—	6
Membership, October 30, 1886		3,102		379
Net gain during the year		230		56
RECEIPTS.				
Balance cash on hand, as per last report		$9,233.30		$ 60.42
Received account of assessments, fees, etc		29,702.15		905.00
Received account of sundries		20		
Received account of interest		3,077.42		10.00
Total income		$42,032.87		$975.42
DISBURSEMENTS.				
Death claims		$24,900.00		$308.70
Bonds account reserve fund		6,757.50		
Medical examinations		253,00		17.00
Fees refunded		21.00		
General expenses		2,766.95		111.82
Total disbursement		$34,698.45		$437.52
Balance cash on hand		7,334.42		537.90
Total		$42,032.87		$975.42
Balance due on assessments, etc		3,109.64		302.00
Reserve fund (par)		$48,000.00		

Heretotore assessments have been levied upon members without regard to the age at which they joined the association. An amendment to the by-laws was adopted at this meeting, however, providing for the grading of assessments of new members after January 1st, 1887, when the amendment takes effect. After that date the assessments will be levied according to the following schedule :

Upon members admitted prior to, and in good standing on January 1st, 1887	$1.00
Upon members admitted on and after January 1st, 1887, whose age at entry shall be between	
18 and 30	1.00
30 and 35	1.25
35 and 40	1.50
40 and 45	2.00

The question of allowing compensation to agents was fully discussed, and the matter was referred to the executive committee for further consideration, with power to allow compensation for the coming year, to an amount not exceeding an aggregate of $500, if, in the judgment of the committee, such action is advisable.

The following officers were re-elected : President, A. R. Brewer ; vice-president, W. H. Young ; secretary, Charles P. Bruch ; treasurer, E. T. Mackay ; members of the executive committee, Jos. Uhrig, Chicago ; C. W. Hammond, St. Louis ;

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W. B. Gill, Philadelphia; J. Merrihew, J. L. Edwards, New York; auditing committee, S. S. Garwood, M. J. O'Leary, W. J. Dealy.

On behalf of the western members, Mr. Uhrig extended an invitation for the association to hold its next annual meeting in Chicago. It was the desire of those present that the next meeting should be held at Chicago, but the laws of New York require the holding of annual meetings in this state. The invitation was, however, accepted, and referred to the executive committee with a recommendation that the meeting be held in Chicago next year, if practicable, even if a meeting be held subsequently in New York to ratify what may be done at Chicago. A vote of thanks was voted to the officers and agents.

REMOVAL OF THE NEW YORK OFFICE OF THE BALTIMORE AND OHIO RAILROAD AND TELEGRAPH COMPANIES.

The Baltimore and Ohio Railroad and Telegraph Companies have taken the Brandreth building, Broadway and Canal street, and will shortly occupy it. We understand that they will consolidate there all their New York business, both railroad and telegraphic.

ELECTRIC LIGHTS TO BE USED IN ALL THE AQUEDUCT TUNNELS.

The Aqueduct commission has taken in hand the matter of lighting the tunnels by the contractors, in view of the serious complaint that has been made of bad light and ventilation.

Some of the contractors have persisted in using gasoline for illumination, causing much complaint on the part of the workmen. The light is alleged to be insufficient, and the burning of gasoline to be very deleterious to the atmosphere in the tunnel. The demand that electric lights shall be used throughout, seems just and reasonable, as does also the requirement that power blowers shall be used for ventilation.

At a meeting of the Aqueduct commission on Nov. 16th, commissioner Ridgeway submitted the following resolutions:

Whereas, Notwithstanding the repeated promises of contractors Brown, Howard & Co. and John Brunton & Co., to comply with the order given under direction of the commission by its chief engineer to light the tunnels under their contracts with electricity and improve their method of ventilation:

Whereas, They have not complied with said order, but, on the contrary, in places where masonry is being put, it frequently appears that they allow the air boxes to be displaced so that there is no provision for the introduction of pure air into the heading; and

Whereas, They still continue the use of gasoline lamps, vitiating the air to such an extent as to make it detrimental to health and life; therefore, be it

Resolved, That this commission take immediate steps to enforce the order issued by the chief engineer to the contractors under date of June 22d and Sep. 9th, directing them to place electric lights and power blowers upon their works.

Mr. Fish seconded the resolution, and after some discussion it was decided to postpone the matter for one week to await the opinion of the corporation counsel as to the best method to be adopted to compel the contractors to do as directed.

ELECTRIC LIGHT AND POWER.

Chattanooga, Tenn., is to have more electric lights.

Millville, N. J., is to be lighted by the Franklin (N. J.) Electric Light Co.

The Iowa City, (Ia.) Electric Light Co., has been incorporated by Mr. Moses Bloom, as president, with a capital stock of $15,000.

Through Mr. H. M. French, general manager, the Ball company, Boston, has made a contract with the proprietors of the Cyclorama of the Battle of Gettysburg there, to put in a plant for the entire lighting of their building. A Ball 25-lighter, 10 ampere current, will be installed with a Southwark engine and a Hodge steel boiler. The same company is installing a plant at Stoughton, Mass.

Westinghouse, Church, Kerr & Co. have closed with the Carbondale Light Heat and Power Company for a station of 1,000 16-candle power lamps. Work is being vigorously pushed.

The Brush Electric Light Company, of Buffalo, see no limit to the electric light business. They have just ordered two more 60 h. p. Westinghouse engines, making 18 in all now running in a single room. Westinghouse, Church, Kerr & Co. are also constructing for them an incandescent central station on the Westinghouse system.

The Norwich Gas Light Co., Norwich, Conn., has purchased a controlling interest in the local electric lighting company.

The Birmingham Gas Light and Illuminating Co., Birmingham, Ala., has ordered an incandescent electric plant.

The Racine Gas Light Co., Racine, Wis., will introduce the electric light. Gas is $1.80 per 1,000' at Racine.

The Roxbury Gas Light Co., of Roxbury, Mass., is supplying electric light, as well as gas light, to its consumers.

The Brookline Gas Light Co., Brookline, Mass., has filed a petition at the office of the secretary of state, for authority to furnish electric light and power in Brookline.

Attica, Ind., is to have incandescent electric lights. Address, Little & Putman.

A system of electric lighting is contemplated at Le Roy, N. Y. C. W. Keeney is interested.

The Charlestown (Mass.) Gas and Electric Light Co. is successfully running its electric light plant. Its steam plant was erected by the Jarvis Engineering Co., Boston, and consists of a six-foot tubular boiler set with the Jarvis patent boiler setting, and an Armington & Sims Co. engine.

A system of electric lights is contemplated at Bay City, Mich. Estimated cost, $30,000. Mayor George H. Schearer is interested.

The Citizens Electric Light Co., Woodbury, N. J., will erect a plant to be completed in two months. President, W. A. Flanigan; secretary, William Norse.

The Common Council, Cohoes, N. Y., contemplate putting in a system of electric lights.

The trustees of Oneida Village, N. Y., have granted a franchise to the American Electric Manufacturing Co., New York, to establish a central station for a system of electric lighting in their village.

Rapid City, Dak., is to be lighted by electricity. O. L. Cooper is interested.

E. L. Gerst has been awarded the contract for an electric light plant at Danville, Va.

The city council, Parkersburg, W. Va., contemplates putting in a system of electric lights.

R. E. Coburn, Valentine Hinrich, and W. J. Patterson, Carroll, Iowa, have been appointed a committee to investigate the practicability of organizing an electric light company.

The Keystone Light and Power Co., of Philadelphia, are just beginning to lay their underground cable, having hitherto used only overhead wires for temporary purposes, working only up to about one-quarter of the ultimate capacity of their plant. They have introduced a handy arrangement for lubricating their three Westinghouse engines and the bearings of the dynamos, which has since been adopted by others. A supply of oil is carried in an iron tank in the boiler room, elevated upon a shelf or platform near the ceiling. To this a pipe, suitably provided with cocks, is attached, connecting with the bearings which it is intended to lubricate, and insuring a constant and economical supply. Not a single squirt-can is used about the place.

Colorado Springs, Col., will be lighted by electricity. W. A. McIntire and C. H. White are interested.

The Kankakee Electric Light and Power Co., Kankakee, Ill., has been incorporated. Capital stock, $20,000. Walter W. Hatch, and others, incorporators.

The Edison Electric Light and Power Co., Kansas City, Mo., has been incorporated. Capital stock, $100,000. Kersey Coates, 1002 Penn street, and others, incorporators.

The Electric Light Co., Hudson, N. Y., has been incorporated. Capital Stock, $30,000. H. Herman Westinghouse, and others, incorporators.

The Worcester Electric Power Co., is building up a good business in supplying power to small manufacturers, printers, tinsmiths, tailors, etc. This company has a large and complete central plant, and string wires to lessees' premises. Power is furnished for $150 per horse-power per year, and the company is now able to put in 2, 4, 6, 10 and 15 h. p. motors. There is a strong and steady demand for 2 h. p. and smaller motors which will soon come into extensive use.

Foreign.

Great Britain.—A correspondent of the Glasgow *Engineer and Trades Advertiser*, writes: The electric tramway opened at Blackpool over a year ago has proved a great success. In order thoroughly to investigate the undertaking, a number of gentlemen visited Blackpool the other day and made a thorough inspection of the line. They were first taken over its whole length of two miles in one of the six cars running daily. The facility with which the vehicle was stopped to take up and set down passengers, and its speed accelerated or reduced, showed a more complete control than that over cars moved by horse-power. The

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line has now been opened for traffic nearly a year, and no accident or delay has occurred in its working. Some of its carriages carry fifty-six passengers, and, while fully loaded, have drawn or driven along the line as rapidly as if drawn by steam, accomplishing the two miles in twenty minutes. As to the financial part of the enterprise, it was ascertained that the cost per mile run was but 4*d.*, and the revenue had reached 2*s.* 6*d.* per mile run. This, of course, was during the season. The company will, it is expected, declare a dividend of five or six per cent. this year.

Germany.—According to the official returns of the Berlin gas-works, there are in that city at this moment 152 installations of electric light embracing 736 arc lights and 12,705 incandescent lamps; of these, 27 arc lights, and 5,499 incandescent lamps are supplied by the Städtische Elektrizitätswerke. Since these returns were published the number of electric lamps has been somewhat increased; still there is as yet but one electric burner at work to every 98 gas burners, supplied from the municipal stations and the works of the Imperial Continental Gas Company.

France.—Electric lighting was introduced in Tours a few months ago. Two motors, which ranged from 100 to 150 h. p. actuate Siemens machines with alternate currents, and the circuit passes through secondary generators, of the Gaulard-Gibbs' type which are put up at the subscribers' houses. Hitherto they have been very satisfactory.

The following interesting statistics of the electric lighting in France have just been published:—

	Number of Installations.	Arc Lamps.	Incandescent Lamps.
Public roads	10	108	140
" edifices	5	—	1.487
Theatres	14	324	3,244
Ships	25	52	5,947
Private houses	28	98	1,594
Shops, cafés	49	763	3,932
Museums	3	2	800
Workshops, etc	903	4,224	33,547
Central stations	7	—	4,630
Photo electric apparatus	—	300	—
	1,044	5,870	55.321

It is stated that the Vatican is to be lighted with electricity, and that Messrs. Siemens & Halske, of Berlin, have received instructions to carry out the work, which is to be completed by the end of this year.

The Laboratoire d'Électricité, created with the surplus of the electrical exhibition of 1881, held in the Palais de l'Industrie, will be erected on the site of the old Collège Rollin, on grounds granted by the city of Paris. It will be open to electricians of every nation, and governed by the international society of electricians.

Austria.—The electric light in the Austrian mines and metallurgical works.—In the Mayrau mine (Kladno) the electric light has been successfully introduced both for the working up of the ores and the charging department. The dynamo now in use supplies ten lamps. The electric signals which have been introduced together with the bell signals, have likewise turned out very successfully. The same thing may be said of the telephone that has been established as a means of communication between the pit-mouth and the place where the ore is loaded. In the Sulkov mine, the Pilsen, nine of Krizik's arc lights have been introduced, and hitherto they have proved very successful. In the Anna and Beust, near Brüx, it appeared expedient to improve the lighting of the loading slopes and of the "manipulation localities." To this effect an electric plant has been put up, consisting of one Gülcher dynamo, No. 2, supplying three arc lamps of 1,375 candle-power each for lighting each of the slopes, and from 5 to 17 incandescent lamps of from 20 to 49 candle-power, for lighting up the localities. Both installations have proved very successful, so has likewise the electric light fitted up in the Guido shafts at Niedergeorgenthal, near Brüx for lighting up the ascents and the loading slopes. In this case there are six Schuckert-Krizik arc lamps, each of 1,250 candle-power. In the Julius mine at Rossitz three large arc lamps have been fitted up for lighting up the loading slope and the metallurgical works, while the incandescent lights are used for lighting the shaft and boiler-houses, the offices, the saw and grinding-mills. In the Heinrichs-Glück mine, at Peterswald, near Ostrau, four arc lamps and 33 incandescent lamps supplied by a Gülcher dynamo, are used for lighting, and a magnetic induction telegraph for signaling purposes between the charging place, the pit mouth, and the engine room. At the government melting works, at Brixlegg, a beginning has been made with the erection of electrolytic works for the extraction of copper and silver. At Witkowitz also a reverberator furnace and a melting furnace for waste metal, have been set up in the electrolytic copper refinery.

Italy—An excellent example of a town undergoing direct transition from oil lighting to electric illumination without passing through the intermediate stage of gas lighting, is presented by the little town of Tivoli, near Rome. The installation has been carried out by the Hydraulic Power Co., of Rome, the motive power being water. The primary circuit is about 18 miles long, and sufficient power is generated for 225 50-c. p. and 76 16-c. p. glow lamps, with 6 arc lamps of 500-c. p. each. These last named are carried on wrought-iron standards some 70 feet high. The secondary generator of Gaulard & Gibbs, is used for distributing the current, a small generator being affixed to each lamp. These generators are of a type specially adapted for street lighting. The success of the lighting is complete, and reflects credit upon the Hydraulic Power Co. of Rome. After a lapse of nearly eighteen months the authorities at St. Martin's-le-Grand, have decided again to endeavor to light the central telegraph and other offices in the city by electricity. It is also intended to light electrically a portion of the galleries; the galleries selected for the experiment being the central hall, on the ground floor, which is entirely devoted to the foreign branch and the pneumatic tube working; the new department, and the special events section, situated on the top floor, and stated to be the busiest departments of the central office.

NEW INCORPORATIONS.

The Seneca Falls Electric Light and Power Co., Seneca Falls, N. Y., has been incorporated. Capital stock, $20,000. Simon S. Phillips, Henry T. Hayes, and others, incorporators.

The Massillon Schuyler Electric Light Co., Massillon, Ohio, has been incorporated. Capital stock, $50,000. J. W. McClymonds, C. M. Russell, and others, incorporators.

The Hamilton Electric Light and Power Co., Hamilton, Ohio, has been incorporated. Capital stock, $50,000. James E. Neal, H. L. Macy, and others, incorporators.

The Newton Electric Light and Power Co., Newton, Mass., has been incorporated. Capital stock, $25,000. Horace B. Parker, and others, incorporators.

The Dayton Edison Light and Conduit Co., Dayton, Ohio, has been incorporated. Capital stock, $100,000. H. H. Hoffman, A. Stuart, and others, incorporators.

The Boise City Electric Light Co., Boise City, Idaho, has been incorporated. Capital stock, $25,000. President, W. P. Chandler.

The Ellsworth Electric Light Co., Ellsworth, Me., has been incorporated. Capital stock, $24,000. President, C. B. Story.

The Brush Electric Light and Power Co., Niagara Falls, N. Y. Capital stock, $30,000. Frederic Spaulding and others, incorporators.

The Harlem Electric Illuminating Co., New York City, N. Y. Capital stock, $100,000. Clinton H. Leggett, and others, incorporators.

The Yonkers-Schuyler Electric Light Co., Yonkers, N. Y., has been incorporated. Capital stock, $100,000. James R. O'Brien, and others, incorporators.

The Excelsior Electric Co., Wilkesbarre, Pa., has been incorporated. Capital stock, $25,000. Treasurer, George W. Shonk.

The Edwards Electric Light Co., has been organized at Richmond, Ind., with $2,000,000 capital stock, to make electric head-lights of the Edwards pattern, for locomotives. The officers of the company are: James W. Carpenter, Dayton, O., president; J. H. Kibbey, vice-president; J. W. Carpenter, Jr., secretary and treasurer; Edgar A. Edwards, Cincinnati, electrician and superintendent. The company purposes building shops at Richmond.

The Torrington Electric Light Co., Torrington, Conn., has been incorporated. Capital stock, $12,000. A. F. Migeon, and others, incorporators.

The Cook County Electric Light Co., Chicago, Ill., has been incorporated. Capital stock, $500,000. Frank H. Collier and others, incorporators.

THE RAILWAYS OF EUROPE.

The subjoined data are taken from a statement respecting the situation of European railways on December 31st of last year, recently issued by order of the French minister of public works. From comparison of the lengths of the railway nets actually worked in the different countries, it appears that the German railway system is the longest of all. Of 121,964 miles of rail worked throughout Europe, no less than 23,459 miles fall to the share of the German Empire. Next in order comes France, with an aggregate length of 20,307 miles, whilst the United Kingdom holds the third place, its railway net having a length of 19,366 miles. The mileage of "all the Russias," including Finland and Transcaucasia, is 16,552 miles; but the strategic line built of late years in Central Asia, and having a length of about 145 miles, cannot properly be classed under the head of European railways. The dual monarchy of Austria and Hungary has 14,138 miles of rail. The length of the Italian railway net is 6,471 miles, and that of the Spanish system 5,741 miles. Sweden and Norway between them command a length of 5,284 miles, whilst the Belgian railway net is 2,756

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miles, and the Swiss 1,724 miles in length. Among the remaining countries of Europe there is not one whose railway net is more than 1,250 miles in length.

At the end of 1884 the aggregate length of railways that were then being worked in Europe did not exceed 118,260 miles. It would appear, consequently, that in the twelve months ending December 31st, 1885, the European railway net increased to the extent of 3,704 miles. The largest portion of this increase falls to the share of France, where 793 miles of rail were opened for public traffic. Russia added 681 miles to her net, which is not bad for the northern empire. The increase of the German lines does not exceed 500 miles during that period. Austria-Hungary did not in 1885 add more than 337 miles to its railway net, and the United Kingdom not more than 326 miles. These figures, however, afford no very safe guidance to judge the progress of the different countries by. In countries like England and Belgium, in which the railways have practically taken the place of the high-roads, it stands to reason that there remains much less work to be done for the navvy and the platelayer than in districts in which railway traffic is still in its infancy. Upon this ground it may be taken for granted that before many years are over there will not be anything like the same disproportion between the areas of various countries and the length of their railway nets, as we still perceive at this day in looking through returns like the one recently issued by the French board of trade.—*Universal Engineer.*

PERSONAL MENTION.

It is a pleasure to record the election of Mr. Enos M. Barton to the presidency of the Western Electric Co. Those acquainted with electrical manufacturing of the past 20 years need not be told of the conspicuous part that Mr. Barton has taken in the business. They will remember the firm of Gray & Barton, and the shop started by them at Cleveland, O., and afterwards moved to Chicago; and how it became the nucleus around which has aggregated the present extensive business of the Western Electric Co. The manufacturing and trade of the company now embrace all branches of electrical appliances. Its products reach all quarters of the world. This development is, in large measure, due to the judgment and sagacity—the long look-ahead—of Mr. Barton and the late Gen. Stager, formerly president of the company, who were coadjutors in the management from the start.

A DECISION IN THE GREAT TELEPHONE SUIT.

THE GOVERNMENT BEATEN ON THE QUESTION OF JURISDICTION.

A decision was announced Nov. 11, in the United States Circuit Court on the question of jurisdiction in the matter of the proceedings brought by the government to annul the Bell patents owned by the American Bell Telephone Co. The decision was against the government upon every point which counsel had raised. The bill was dismissed, but without prejudice, which leaves the government in the same position it was in before the suit was brought, except that if another suit is brought it must be in Massachusetts, the home of the Bell company, and not in any state the government may choose where the Bell company's instruments are in use.

THE FRENCH PRIZE FOR ELECTRICAL DISCOVERY.

By a decree dated June 11th, 1882, the government of France offered a reward of 50,000 francs for the discovery of greatest value relating to the utilization of electricity for any of the following purposes: As a source of heat, of light, or of chemical action; as a means of transmission of mechanical power, or of verbal communication in any form; or, finally, as a curative agent. The minister of instruction has now announced that June 30th, 1887, will be the latest date for entering the competition, and that the prize will be awarded in the following December. The competition is open to all without restriction, and *savants* of all nations are invited to participate in the award.

MANUFACTURING NOTES.

The Chrome Steel Works, of Brooklyn, N. Y., have concluded to substitute gas for coal in their heating furnaces. It will be necessary to tear out their old furnaces, and put in "regenerators" in their stead. The new plant will be complete in every respect, even to apparatus for the manufacture of the necessary gas, which will be made on the premises. This improvement will increase the productive capacity of the works two-fold.

The Edison machine shops, which began operations on the 11th ult. at Schenectady, will, as soon as all the necessary machinery can be put up, give employment to upwards of 1,000 men. The plant consists of two brick buildings, one 80x200, and the other 100x220 feet, and a third building, 147x50 feet, will be erected. There are ten acres of land belonging to the property, which was purchased last June for $45,000—about half its value—after the McQueen Locomotive Co., for which the buildings were erected, but which never began business, went into the hands of a receiver. The Edison Co. consists of Thomas A. Edison, Charles Batchelor, John Kreusi, H. M. Livor, Samuel Insul, and J. Pierrepont Morgan, and has a paid-in capital of $750,000. The business is the manufacture of machinery, shafting, pulleys and hangers, and all kinds of electric-light apparatus except lamps. In time, all branches of the business will be consolidated in Schenectady. Mr. John Kreusi is general superintendent of the works, and C. M. Turner is superintendent of the construction department. The machinery will be run by four engines, aggregating 250 h. p. The employés will be nearly all skilled mechanics, and paid from $1.60 to $2.50 per day.

A bronze medal was awarded Messrs. Chas. A. Schieren & Co., of New York, at the international exhibition at Liverpool, October, 1886, for electric leather belting. Messrs. Schieren & Co. have recently furnished belting for electric light plants as follows:

Morristown Electric Light and Power Co., Morristown, N. J.
Thomson-Houston Electric Light Co., Philadelphia, Pa.
Excelsior Electric Company, Plymouth, Pa.
Babylon Electric Light and Power Co., Babylon, L. I.
Thomson-Houston Electric Light Co., Seneca Falls, N. Y.
Fall River Electric Light Co., Fall River, Mass.
Natick Electric Light Co., Natick, Mass.
Narragansett Electric Light Co., Providence, R. I.
Elmira Electric Light Co., Elmira, N. Y.
Bartholdi Statue Electric Light Plant, New York Harbor.

Messrs. Blodgett, Bros. & Co., Boston, are making a signal clock for starting railway trains. It automatically switches itself into a special time-table on Sunday, and back again to the week day table on Monday.

The Westinghouse Electric Co. have purchased the extensive manufactory of the Union Switch and Signal Co., which covers half a square on Duquesne Way, and Garrison Alley, Pittsburg, and will at once largely increase its facilities for manufacturing dynamos, incandescent lamps and fixtures. The main building is five stories high, and the property comprises two other large buildings one of brick and one of iron. Some alterations and additions will be made in the property by the Westinghouse company. The price paid is reported to be in the neighborhood of $175,000.

The Union Switch and Signal Co. of Pittsburg, have sold their factory to the Westinghouse Electric Co., and have purchased the property eight miles east of Pittsburg, on the Pennsylvania railroad, formerly occupied by the Swissvale Car Co., comprising seven acres of land, with extensive and convenient buildings. This change will not only largely increase the manufacturing facilities of the company, but will effect important economies in its expenses, in the way of transportation and taxes.

INTERNATIONAL RAILWAY EXPOSITION AND CONGRESS, PARIS, 1887.

An international exposition will be held in Paris, from May to October, 1887.

This exposition will comprise the various industrial and professional branches connected with railways, such as engineering and mechanics, locomotives, machinery, passenger coaches and freight cars, hoisting and wrecking apparatus, apparatus for heating and lighting, apparatus for intercommunication, couplers and other railway appliances, building, furnishing and conveyance material, metallurgical and electrical apparatus, etc., etc.

At the same time, an international railway congress will be held by delegates from railway companies, chambers of commerce, scientific and professional societies, for the discussion of important questions of management, exploitation, maintenance, rolling stock, security, traffic, etc., etc.

Manufacturers, and all others interested, in the United States, have an opportunity to coöperate, in order to secure such an exhibit as will enhance their prospects of foreign trade, and at the same time display the progress of their country.

Mr. John W. Weston, 230–236 La Salle street, Chicago, has been appointed Commissioner-General for the United States.

AN INTERESTING DECISION IN A PATENT SUIT.

The uncertainty of patent litigation, even upon a patent that has been sustained, is well exemplified in the opinion recently filed (July 19, 1886), U. S. Circuit Court, S. D. New York, in the case of Colgate *vs.* The Western Electric Mfg. Co.

The suit was brought some six years ago on the Simpson patent No. 65,019, of 1867, on gutta-percha insulated wire. By decree in January, 1882, the patent was held good and valid, defendant was held to have infringed, and a reference was made to a master to take an account of defendant's profits and complainant's damages.

Though proofs were taken upon the accounting in New

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York and Chicago from time to time for more than three years, Colgate was not able to show what profits, if any, defendant had made by its infringements. Therefore, under the law, unless he showed that he had an established rate of license fee, he was not entitled to recover anything as damages.

The master found that defendant had sold a certain amount of gutta-percha covered wire, of which somewhat more than half had been purchased by them from parties who were licensed. As to the portion not so purchased of licensees, the master found that the defendant should pay 10 per cent. as damages. In the testimony before the master the complainant produced agreements with various parties licensed, reciting terms of royalty. Defendant produced evidence to show that substantially the whole of the wire in question was sold by them to parties licensed to use.

Defendant filed exceptions to the finding of the master. The exceptions were, in substance, first, that the master erred in finding that the complainant had an established rate of license fee for the sale of the wire—and second—that defendant ought not to pay royalty or damages upon wire sold to parties licensed to use.

The decision referred to above is upon the exceptions of defendant to the master's findings. The opinion is as follows:—

WALLACE, *J.* The Master has awarded damages to the complainant upon an accounting for the infringement of his patent for insulated wire upon the basis of a royalty. The infringement by the defendant consisted in the sale of the article.

The proofs of the complainant may show that he has an established license fee for the use of his invention, but they wholly fail to show that he has any uniform established license fee for the right to sell the article.

The complainant testifies in general terms that he has an established license fee, and grants licenses to sell his invention for a royalty of 10 per cent. upon the gross cost of the articles sold; but he names as licensees several corporations, railroad and municipal, not manufacturers or trading concerns, whose operations may require them to use the invention; and when he is pressed to produce documentary evidence, he presents agreements which are licenses to use the invention for specified purposes, with the exception of four. Two of the four are releases of the past infringements.

Royalty paid by licensees for the right to use the invention is not evidence of damages sustained by the patentee by the sale of the patented article sufficient to authorize a recovery. The value of some patents consists principally in the right to use the invention, the value of others in the right to sell; and infringement by selling and infringement by use of the patented article are essentially different invasions of the patentee's property.

The complainant's case, consequently, rests on the effect of the two remaining agreements introduced by him for the purpose of showing his established license fee for the right to sell under his patent. These are the agreements with the Bishop Gutta Percha Works and the Laflin & Rand Powder Co. The agreement with the Bishop Gutta Percha Works grants the exclusive right to manufacture and sell the patented article to that company, and contains a covenant not to sue purchasers from that company buying for certain specified uses of the invention; and, in consideration therefor, the company is to pay a royalty of five per centum of the gross price received from sales. This agreement was subsequently modified by adding a covenant not to sue purchasers from the company for certain other specified uses of the invention, and by increasing the royalty on the sales to purchasers for such uses to 10 per cent. of the gross price received by the company. The agreement with the Laflin & Rand Powder Co. is a grant of the privilege to manufacture and sell the invention to purchasers for specified uses, with a covenant not to sue such purchasers, and the company agrees to pay a royalty of 10 per centum of the gross price of manufacture to the complainant, and an equal royalty to the Bishop Gutta Percha Works, which company is a party to the agreement.

Royalty paid for the whole monopoly of selling and manufacturing under a patent is not sufficient evidence of the value of the right to make occasional sales in a particular territory: Le Bau *v.* Hawkins, 2 B. & A. 561. An exclusive licensee may well afford to pay a much larger consideration for the property right than the patentee could command from purchasers of a license to compete with other sellers. But, aside from this consideration, which is alone sufficient to deprive the agreement with the Bishop Gutta Percha Works of any weight as evidence of an established royalty, the agreement contains a covenant not to sue purchasers from the licensee. The agreement with the Laflin & Rand Powder Co. contains a similar covenant upon the part of the complainants. Such a covenant operates by way of estoppel to license the purchaser to use the patented article. Both of these agreements are, therefore, equivalent to a license to sell and transfer to purchasers the right to use the invention for the purposes specified. Royalty paid for such an interest in the property right is not the criterion of the value of an ordinary selling right. The right to sell might be of insignificant value without such a covenant as is contained in these agreements. Ordinarily, it would only be a right to sell a lawsuit, or the limited privilege of selling to customers having a license to use the article. With such a covenant the value of the right is greatly enhanced, because the seller can transfer to the purchaser the privilege of using the invention.

There are other reasons why these two agreements fail to afford such evidence of a unform established license fee as to entitle the complainant to the damages found by the Master. It is not necessary for present purposes to suggest them.

The defendant's exceptions are sustained.

FREDERIC H. BETTS, for complainant.
GEORGE P. BARTON, for defendant.

This opinion, it will be seen, sustains the first exception of the defendant to the Master's finding. An opinion on the defendant's second exception, viz.: That it ought not to pay royalty on wire sold by it to parties licensed to use, would, perhaps, have been still more interesting.

The above opinion is summarized by the *Chicago Legal News*, as follows:

1. Royalty paid by licensees for the right to use the invention is not evidence of damage sustained by the patentee by the sale of the patented article sufficient to authorize a recovery, and infringement by selling and infringement by use of the patented article are essentially different invasions of the patentee's property.

2. Agreements containing a covenant not to sue purchasers from the licensee operate by way of estoppel to license the purchaser to use the patented article.

On November 17th judgment was entered in the above case in favor of defendant for costs, $411.79.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICIAN AND ELECTRICAL ENGINEER, *by* Pope & Edgecomb, *Solicitors of Patents for Electrical Inventions*, 11 *Wall Street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From October 19th to November 16th, 1886 (inclusive).

Alarms and Signals:—*Annunciator*, C. H. Dowden, 351,099, October 19; *Burglar Alarm*, P. K. Stern, 351,408, October 26; J. W. Hoffman, 351,772, November 2; C. H. Dowden, 352,861, November 16. *Electric Temperature-Alarm and Thermostat*, W. H. Stiegelmaier, 351,134, October 19. *Electro-Mechanical Signal Apparatus*, W. W. Le Grande, 351,384, October 26, and 352,903, November 16. *Electric Bell and Alarm*, A. Lungen, 352,472. *Electric Alarm for Time-Pieces*, F. Glasgow, 352.407, November 9. *Electric Alarm Clock*, F. E. Derrick and S. C. Brott, 351,746, November 2. *Electric Vibrating Call or Signal*, C. Henzel, 351,599, October 26. *Fire Alarm Apparatus*, E. L. Slocum, 351,075, October 19. *Rapid Fire-Signal*, T. F. Gaynor, 352,645, November 16. *Thermostats*, L. B. Stone, 351,719, October 26; G. F. Bulen, 352,442, November 9. *Watchman's Electric Signal Box*, W. W. Le Grande and G. W. Burton, 352,549, November 16.

Clocks:—*Electrical Time-Piece*, S. Thackara, 351,222. *Pendulum for Electric Clocks*, J. J. Abell and C. B. Gifford, 351,239, October 19. *Secondary Electric Clock*, J. F. Hedge, Jr., 352,320, November 9.

Conductors, Insulators, Supports and Systems:—*Distribution of Electric Currents*, E. Thomson, 350,958, October 19. *System of Electric Distribution*, L. Gaulard and J. D. Gibbs, 351,589, October 26; J. W. Howells, 352,691, November 16. *Electric Conductor*, E. D. McCracken, 351,191. *Machinery for Covering Electrical Conductors*, same, 351,192. *Underground Electric Conductor*, same, 351,193, October 19. *Conductor for Telephones*, A. A. Knudson, 351,704. *Reel for Electric Conductors*, J. M. Bowyer, 351,488. *Compound for Insulating Telegraph-Wires, etc.*, R. Alexander, 351,611. *Underground Conduit for Electric Wires*, F. V. Greene, 351,697, October 26. *Protecting Underground Wires and Pipes*, W. Haddock, 351,918, November 2. *Electric Insulator*, H. D. Winton and W. Hills, 352,436 and 352,437. *Composition for the Manufacture of Blocks for Containing Electric Wires or Cables*, J. W. Butler, 352,445, November 9. *Line Connection for Mechanical Telephones*, G. F. Shaver, 352.577. *Flexible Joint for Underground Electrical Conduits*, S. E. Hurlbut, 352,754. *Underground Tube for Electric Wires*, H. G. Morehouse, 352,771. *Insulating Material for Electric Wires*, D. Brooks, Jr., 352,852. *Machine for Connecting Wires*, A. L. Brush, 352,853, November 16.

Dynamos and Motors:—*Dynamo-Electric Machine*, H. E. Walter, 351,544, October 26. *Magneto-Electric and Electro-Magnetic Machine*, R. Eickmeyer, 351,902, 351,903 and 351,904. *Dynamo-Electric Machine or Electric Motor*, same, 351,906, November 2. *Electro-Magnetic and Magneto-Electric Machine*, same, 352,234, November 9. *Regulator for Dynamo-Electric Machines*, N. Tesla, 350,954. *Commutator for Dynamo-Electric Machines and Electric Motors*, P. Diehl, 351,167. *Electric Motor*, H. Walter, 351,2[illegible], October 19. *Safety Attachment for Dynamo-Electric Machines*, L. G. Woolley, 351,419. *Reversing Gear for Dynamo-Electric Machines*, E. [illegible] Houghton and T. M. Collet, 351,699, October 26. *Automatic Electric Current Regulator*, C. F. Brush, 351,961. *Commutator Brush*, C. J. Van Depoele, 352,074, November 2.

Galvanic Batteries:—*Electric Battery*, C. J. Hirlimann, 351,602, October 26. *Galvanic Battery*, J. W. Hoffman, 352,324; W. R. Patterson, 352,486, November 9; E. J. Leland, 352,877, November 16.

Ignition:—*Electrical Gas Lighter*, A. Lungen, 352,473, November 9. *Electric Igniter for Gas Engines*, C. W. Baldwin, 352,796, November 16.

Lamps and Appurtenances:—*Electric Lamp*, W. S. Hill, 351,601, October 26; T. A. Edison, 351,855; A. T. Gifford, 351,973, November 2; D. Lyman and M. Wheeler, 352,625, November 16. *Arc Lamp*, E. B. Cutten, 350,975, October 19. *Incandescent Electric Lamp*, T. A. Edison, 351,856; W. P. Kookogey, 351,869; F. Schaefer, 352,006 and 352,007, November 2. *Electric Lighting Apparatus*, A. C. Ferguson, 351,369, October 26. *Arc and Incandescent Electric Lighting*, H. P. Brown, 352,035, November 2. *Cut-Out Apparatus for Electric Lamps*, E. Thomson, 350,955, October 19. *Cut-Out for Incandescent Lamps*, H Lemp and M. J. Wightman, 352,621. *Thermostatic Cut-Out for Incandescent Lamps*, same, 352,622, November 16.

Miscellaneous:—*Automatic Compensator for Magnets*, E. Thomson, 350,956, *Electro-Magnet*, same, 350,957. *Induction Coil*, F. F. Stogermayer, 351,077. *Electric Belt*, H. W. Watkins, 351,233. *Electro-Magnet*, M. G. Farmer, 351,256, October 19. *Electric Current Indicator*, R. H. Mather, 351,388. *Electrical Door Opener*, C. Henzel and W. Wood, 351,600. *Electric Time Detector*, J. C. Wilson, 351,681. *Electric Valve*, W. S. Johnson, 351,702. *Electro-Magnetic Regulator*, T. E. Adams, 351,351, October 26. *Device for Taking Electric Currents from or to Moving Surfaces*, R. Eickmeyer, 351,907. *Circuit-Closer*, H. B. Cox, 352,043. *Eectro-Mechanical Whistle*, same, 352,044. *Magnetic Tack-Hammer*, A. R. Robertson, 352,070. *Medical Induction Coil*, L. Drescher, 352,084. *Electrical Ticket-Exhibiting Machine*, H. J. Ennis, 352,086. *Induction Coil*, K. Zipernowsky and O. T. Blathy, 352,105, November 2. *Electrical Door-Opener*, D. Rousseau, 352,154. *Electrical Safety-Attachment for Steam Boilers*, R. Reichling, 352,208. *Apparatus for Steering Ships*, J. A. Tilden, 352,374. *Electric Device*, A. Lungen, 352,474. *Protector for Electric Wires and Instruments*, G. W. Mingle and W. T. Brown, 352,342, November 9. *Hinge Connection for Electrical Instruments*, G. W. Wilson, 352,596. *System of Temperature Regulation*, W. S. Johnson, 352,874. *Automatic Electric Liquid-Level Indicator*, J. J. Ghegan, 352,647. November 16.

Railways and Appliances:—*Electrical Railway*, E. E. Ries, 352,265. *System of Motors for Electric Railway-Brakes*, C. J. Van Depoele, 352,167, November 9. *Electric Railway Signal*, J. H. Gibson, 351,319, October 19; S. C. Mahanay and B. L. Campbell, 352,700; C. W. Pridham, 352,571, November 16. *Train Signal System*, E. S. Graver, 351,759, November 2. *Electro-Magnetic Car-Brake*, H. S. Park, 351,650, October 26. *Duplexing Railway-Telegraphs*, L. J. Phelps, 351,524 and 351,525, October 26.

Secondary Batteries:—*Storage Battery*, O. A. Moses, 352,708, November 16.

Telegraphs:—*Printing Telegraph*, J. H Linville, 350,983 and 350,984, October 19. *Printing Telegraph System*, J. C. Wilson, 352,435, November 9. *Telegraph Key*, J. M. Biggs, 351,485, October 26; M. R. Jenkins, 351,834, November 2. *Telegraphic Relay*, G. Westinghouse, Jr., 352,725. *Telegraph Instrument*, C. G. Wright, 352,600, November 16. *Telegraph Sounder*, C. D. Haskins, 352,317, November 9. *Steno-Telegraph Instrument*, W. A. Kaler, 352,059. *Quadruplex Telegraph*, J. M. Moffatt and E. Blakeney, 351,933, November 2. *Duplex and Quadruplex Telegraphy*, S. P. Freir, 352,865, November 16.

Telephones, Systems and Apparatus:—*Telephone*, P. Seiler, 351,209; M. G. Farmer, 351,258, October 19; R. Eickmeyer, 351,905, November 2; W. R. Cole, 352,735, November 16. *Telephone Transmitter*, W. R. Cole, 351,250, October 19; E. Berliner, 351,569, October 26; W. H. Collins, 352,119; J. W. Bouta, 352,176, 352,177, 352,178 and 352,179, November 9; M. Wheless and J. D. Darden, 352,900, November 16. *Microphone Transmitter*, W. R. Cole, 352,806, November 16. *Telephone Repeater*, M. G. Farmer, 351,257, October 19. *Telephone System*, N. C. Heissler, 351,597. *System of Telephony and Telegraphy*, C. Langdon-Davies, 351,367. *Mechanical Telephone System*, M. G. Farmer, 351,588. *Arm-Support for Telephone Operators*, C. K. Mead, 351,389, October 26.

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